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AUGUST 15, 1994

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INTEGRATED PROPULSION TECHNOLOGY DEMONSTRATOR

PROGRAM PLAN

REVISION: ORIGINAL

DATE: ________

NASA Principal Investigator	Rockwell Principal Investigator
NASA Program Manager Reusable Launch Systems	Rockwell Chief Engineer Advanced Launch Systems

MARSHALL SPACE FLIGHT CENTER

Rockwell Aerospace

(NASA-CR-196870) INTEGRATED PROPULSION TECHNOLOGY DEMONSTRATOR. PROGRAM PLAN (Rockwell International Corp.) 91 p

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INTEGRATED PROPULSION TECHNOLOGY DEMONSTRATOR - PROGRAM PLAN -

1. INTRODUCTION

The NASA and Rockwell has embarked on a cooperative agreement to define, develop, fabricate, and operate an integrated propulsion technology demonstrator (IPTD) for the purpose of validating design, process, and technology improvements of launch vehicle propulsion systems. This program, a result of NRA8-11, Task Area 1A, is jointly funded by both NASA and Rockwell and is sponsored by the Reusable Launch Vehicle office at NASA Marshall Space flight Center. This program plan provides to the joint NASA/Rockwell integrated propulsion technology demonstrator (IPTD) team a description of the activities within tasks / sub tasks and associated schedules required to successfully achieve program objectives. This document also defines the cost elements and manpower allocations for each sub task for purpose of program control.

This plan is updated periodically by developing greater depth of direction for outyear tasks as the program matures. Updating is accomplished by adding revisions to existing pages or attaching page revisions to this plan. In either case, revisions will be identified by appropriate highlighting the change, or specifying a revision page through the use of footnotes on the bottom right of each change page. Authorization for the change is provided by the principal investigators to maintain control of this program plan document and IPTD program activities.

2. IPTD PROGRAM ORGANIZATION AND MANAGEMENT

The principal investigators for the IPTD program are Tim Gaynor for Rockwell, and Hugh Campbell for NASA. They are responsible for overall planning managing, and reporting of activities associated with the IPTD within their respective organizations. However the program plan will be jointly developed and updated with contributions to the program plan provided by members within each organization.

Program activities will be conducted in a product team environment. The team leaders from both NASA and Rockwell for each major task area is shown in Figure 1 The team leaders are responsible for preparing task descriptions and task planning data. They are also responsible for tracking progress of assignments and budget within their task during the program. Sub teams will focus on activities within a specific sub task area with team leaders drawing on expertise from throughout Rockwell and NASA as the need arises. In general terms, the responsibility of NASA and Rockwell per task area is presented in Table 1. However responsibility to provide specific products or resources will depend on the specific assignment, and the ability of a specific organization to satisfy the need at a minimum cost.

3. PROGRAM NEED, OBJECTIVES, AND SIGNIFICANCE

Top-level rocket engine and propulsion system requirements and interfaces typically are defined early in the concept development phase. However, a means of validating these and defining achievable lower-level requirements is not available at this early phase. Development cost growth occurs because of changes late in the program. The consequences of failing to achieve original requirements are either higher system operational costs, reduced capability, or both. This project will enable NASA to develop system requirements and validate vehicle, engine, and subsystem requirements necessary to enhance the credibility of operational cost projections for the SSTO.

The main propulsion system (MPS) is a significant factor in both the inert weight, turnaround time, and operations cost of an SSTO vehicle (Figure 2). Therefore, uncertainty in being able to satisfy projected requirements in this area will have a major impact on determining SSTO feasibility. Uncertainty also exists in correlating the actual operational benefits to various MPS component technology improvements. Predicted benefits due to either technology, process, or design improvements must be evaluated at an integrated system level by trading performance for operational efficiency.

To satisfy this need, this cooperative NASA/Rockwell program has three key objectives:

- Develop a set of test objectives and plans that address operational and performance issues associated with SSTO propulsion systems, including main engine/system interactions.

- Fabricate, assemble, and operate an IPTD from which engine, vehicle, and ground systems operations and performance data, scaleable to an operational SSTO, can be obtained.

- Use test data to optimize the flight system design and interfaces and incorporate proven hardware/test learning into vehicle/operational design characteristics.

Achieving these objectives will provide the SSTO system designers with the credible operations cost data necessary. As the SSTO concept continues to mature through system-level trade studies, lower-level propulsion system design requirements will be established. Implicit in this process is the demonstration of design, process, or technology improvements necessary to achieve system operations cost and performance goals. The IPTD also will establish the new capability of an integrated test article to support SSTO development and the needs of other programs. These include validating MPS improvements for Shuttle and low-cost expendable launch vehicle designs.

4. GENERAL PLAN OF WORK

The program approach has been formulated to establish test and demonstration requirements traceable to SSTO system needs, with a focus on reducing MPS operations costs. The IPTD will be developed and used to perform these tests over a 4-1/2-year period. Data gathered will range from initial automated LO_2/LH_2 tanking time lines to the eventual validation of the performance and operational requirements of a fully functional tripropellant propulsion system supporting sub scale engine demonstrators from Task Area 1a.

4.1 TASK LOGIC AND APPROACH

The program consists of four primary tasks all interrelated as shown in the task logic flow (Figure 3. Tasks 1 through 3 each address one of the three program objectives presented in Section 3, and Task 4 provides for program management.

In Task 1, the NASA/Rockwell team will define a set of SSTO system improvement needs and associated IPTD preliminary design requirements. Test objectives are then developed based on the data required to quantify or validate improvement needs. These test objectives and corresponding data requirements, specified by the analytical studies in Task 3, are the basis for developing test plans and procedures.

In Task 2, the design, fabrication, and assembly of tank, subsystem, and thrust modules of the IPTD will be performed based on Task 1 test objectives and preliminary design requirements. A typical representation of this configuration is presented in Figure 4. Prototype subsystems such as orbital maneuvering system (OMS)/reaction control system (RCS) and power generation units can also be added as options to this program and installed into the subsystem module. An automated propulsion system checkout and control system (PCCS) is also developed in this task and will be used to support Task 2 test operations and data acquisition activities.

The design approach is based on the need to provide an affordable integrated propulsion system demonstrator that is functionally similar to a full-scale flight system to enable credible operations and performance test and analysis. This is achieved by defining a single-engine subset of a typical SSTO propulsion system and using Shuttle MPS components to the maximum extent possible when assembling the IPTD. If additional funds are made available to the IPTD program, these Shuttle MPS components will be replaced with proof-of-concept technology prototypes provided by concurrent advanced component technology programs. Example advanced components which may be incorporated in the IPTD include valve electromechanical actuators (EMAs), advanced leak detectors, and composite feed lines.

In Task 3, operational requirements using inputs from Kennedy Space Center (KSC) will be established and used to define checkout procedures and develop preliminary test plans in Task 1. These procedures will be continually updated to reflect changes in hardware composition during the Task 1 development of detail test plans. Data requirements are established in Task 3 based on those required to either develop or validate propulsion performance and operability models. Test data generated in Task 2 are used in Task 3 to predict the operational and performance characteristics of the full-scale SSTO vehicle.

Program management activities are conducted in Task 4. Included in this task are the coordination and tracking of schedules, budgets, and products associated with the performance of Tasks 1 through 3 during each program phase. However, each task team leader will be responsible for assigning and tracking activities within their respective tasks. They are also responsible for allocating and tracking budget expenditures such as manpower, travel, and material purchases.

4.2 TASK SCHEDULE AND PRODUCTS

The program consist of a basic and four renewal program funding periods. The basic period extends from the July 18, 1994 ATP through the end of FY 94. Each renewal period occurs at the beginning of each fiscal year from FY 95 through FY 99. Within this funding structure, the program has been divided into five program phases;

- Phase 0 (July 94 - February 95), Requirement Definition and Preliminary Design
- Phase 1 (March 95 - December 95), Boattail Design and Fabrication
- Phase 2 (January 96 - December 96), Boattail Integrated Tests, and Tank Fabrication
- Phase 3 (January 97 - December 97), Tripropellant Integrated Cold Flow Tests
- Phase 4 (January 98 - December 98), Integrated Engine / Systems Tests

The four tasks described above are performed during each program phase (Figure 5) and produce interim products such as test readiness reviews or design reviews many which precede critical events such as hardware fabrication and test operations. A set of interim products has been identified as billing milestones (Table 2) which is the basis for funding increments to be provided to the program throughout the basic and renewal periods.

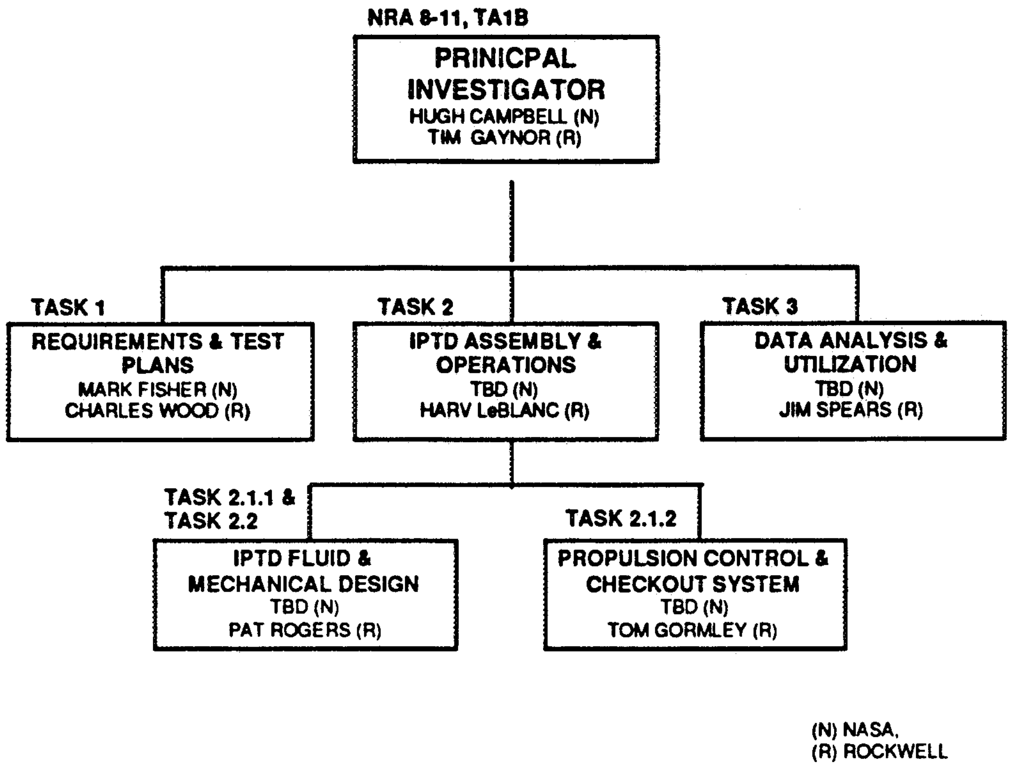


Figure 1, Task Team Leaders Have Been Identified

Table 1, Summary of NASA and Rockwell Roles and Responsibilities

SOW TASK	RESPONSIBLE ORGANIZATIONS					
	ROCKWELL	MSFC	KSC	LERC (1)	ARC (2)	ENGINE (3) CONTRACTOR
1.1 Identify system improvements	List options	Review and agree	Operations support	Support	Support	Support
1.2 Identify test objectives	Test objectives	Review and agree	Operations support	Support	Support	Support
1.3 Test plans	Support plans	Test plans	Operations support	Support	Support	Support
2.1 IPTD design	Design	Review and agree	Review	Review	Review	Input
2.2 Fabrication and installation	Fabricate	Install	---	Support	Support	---
2.3 Test	Analyze Data	Test	Support test	Support	Support	Support
3.1 Analytical models	Models and database	Access models	Review	Review	Review	Review
3.2 Extrapolate data	Scale data/predict	Access credibility	Review	Review	Review	Review
3.3 SSTO requirements	Define requirements	Review and agree	Review	Review	Review	Review
4.1 Program management	Manage program					

Lead organization (shaded)

(1) Focus on LH2 densification GSE assembly and operation and smart sensors only.
(2) Focus on real-time embedded fault tree diagnostics only.
(3) Assume funded under Task 1A - provides engine requirements, Task 1A plans, reviews data

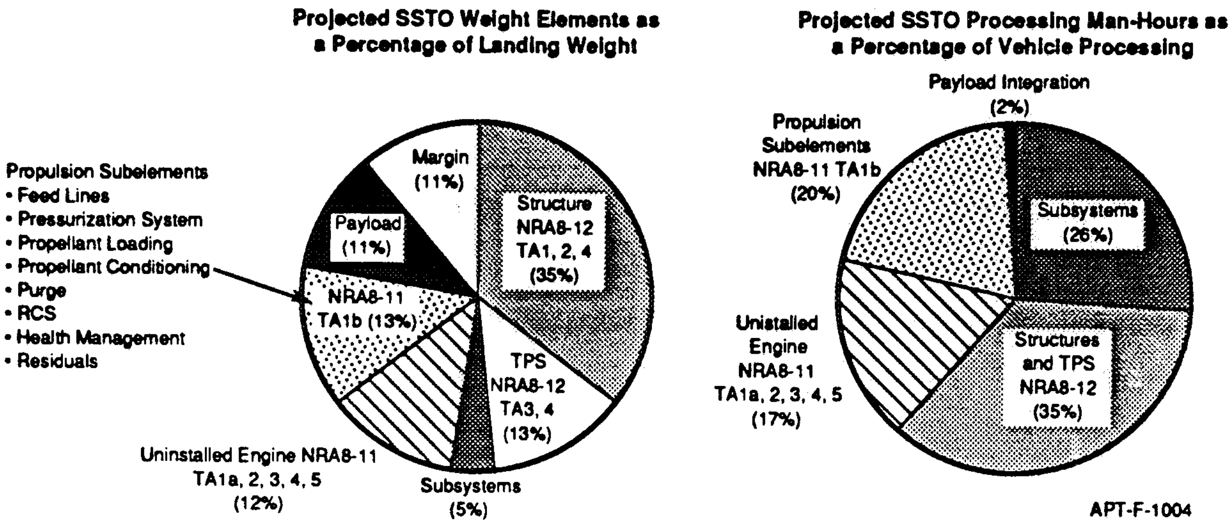


Figure 2 MPS Is a Significant Factor Affecting SSTO Performance and Operability

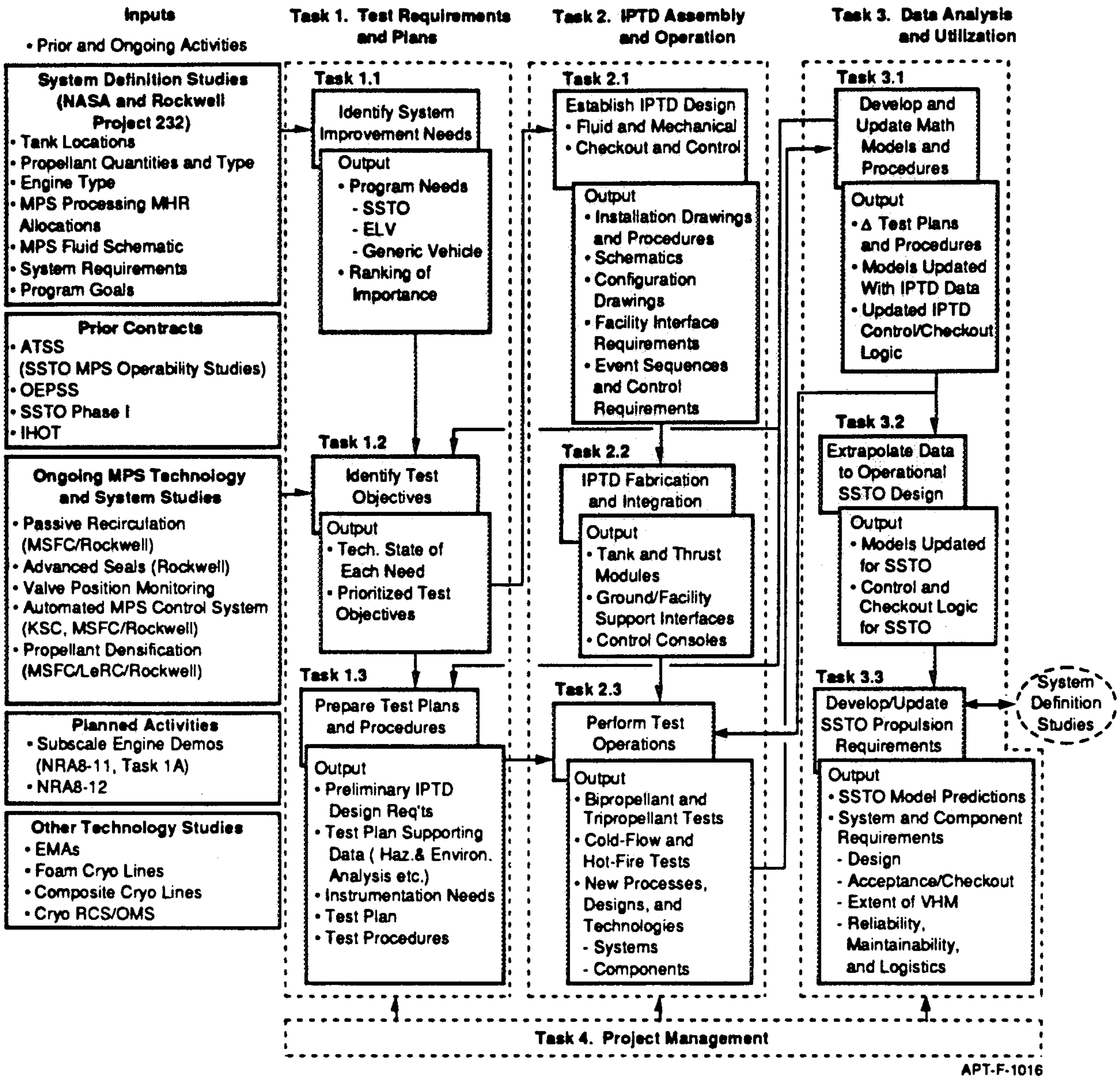


Figure 3 Study Logic Develops Empirically Derived Propulsion Requirements Based on SSTO System Needs

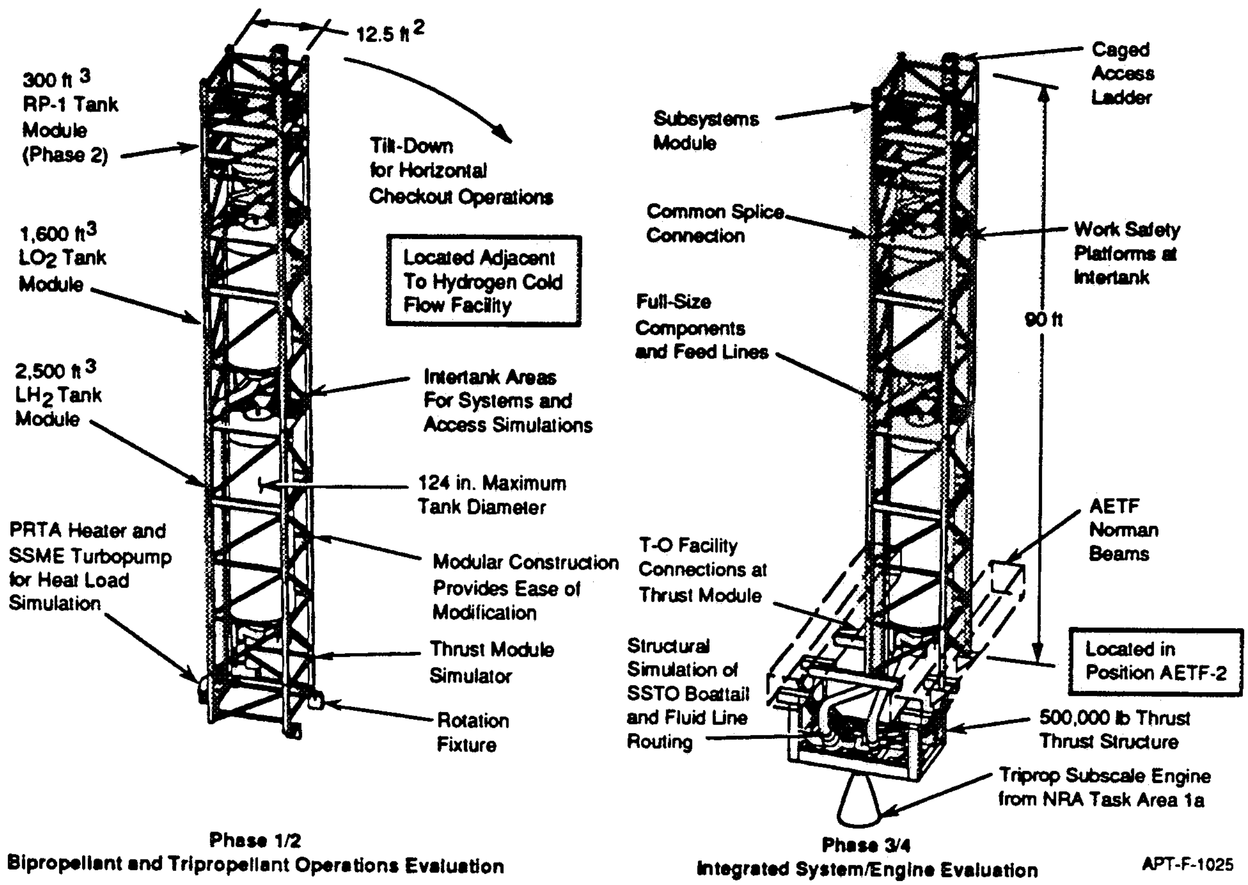


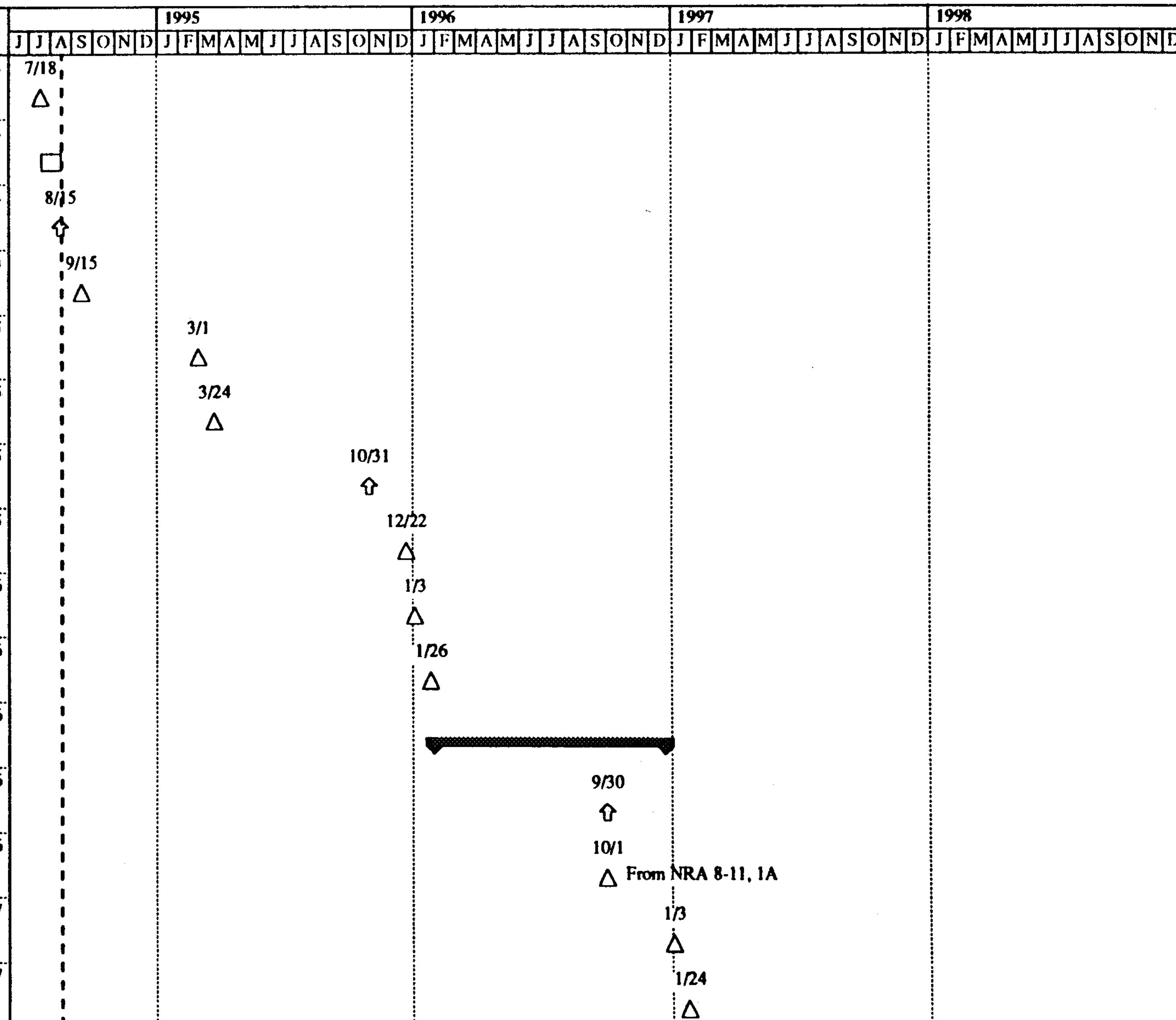
Figure 4 IPTD Design Evolves Over Four Program Phases

NRA 8-11 TA1B

Integrated Propulsion Technology Demonstrator

Program Schedule Summary

ID	Description	Start	Finish
2	ATP	7/18/94	7/18/94
3	Develop Program Plan	7/18/94	8/15/94
4	Submit Draft Program Plan	8/15/94	8/15/94
5	Signoff Program Plan	9/15/94	9/15/94
11	Initiate Phase 1 (Boat Tail Design & Fab.)	3/1/95	3/1/95
12	Update Program Plan for Phase 1	3/24/95	3/24/95
16	Ship Propulsion Module To MSFC	10/31/95	10/31/95
18	Test Sequence (TS) # 1 Test Readiness Review	12/22/95	12/22/95
19	Initiate Phase 2 (Boat Tail Integ. Tests & Tank Fab.)	1/3/96	1/3/96
21	Update Program Plan for Phase 2	1/26/96	1/26/96
214	2.3.1 Conduct Boat Tail Integ. Test (TS#1) at MSFC HCF	1/31/96	12/23/96
28	Ship LH2/LO2 Tank Module To MSFC	9/30/96	9/30/96
29	Acquire Engine I/F Final Spec.	10/1/96	10/1/96
31	Initiate Phase 3 (Tri-Propellent Integ. Cold Flow Test)	1/3/97	1/3/97
33	Update Program Plan for Phase 3	1/24/97	1/24/97



Program Schedule Summary (FIGURE 5)

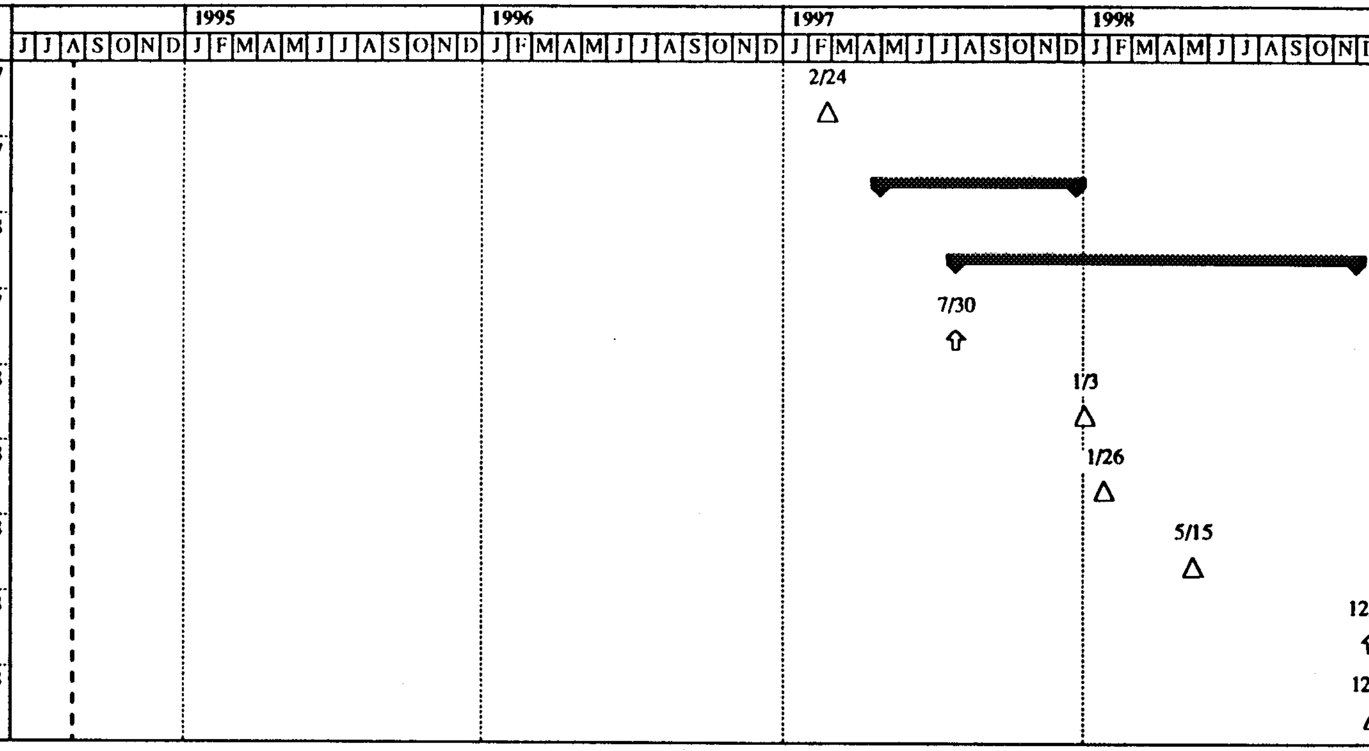
Date: 8/16/94;11:20 am

NRA 8-11 TA1B

Integrated Propulsion Technology Demonstrator

Program Schedule Summary

ID	Description	Start	Finish
34	TS # 2 Test Readiness Review	2/24/97	2/24/97
219	2.3.2 Conduct Tri Propellent Integ. Cold Flow Test (TS#2) at MSFC HCF	4/30/97	12/23/97
224	2.3.3 Conduct Integrated Engine Sys. Test (TS#3) at MSFC AETF	7/30/97	11/30/98
39	AETF/IPTD Integration Design Complete	7/30/97	7/30/97
43	Initiate Phase 4 (Integrated Engine Sys. Test)	1/3/98	1/3/98
45	Update Program Plan for Phase 4	1/26/98	1/26/98
47	TS # 3 Test Readiness Review	5/15/98	5/15/98
53	Final Program Review & Report Submittal	12/20/98	12/20/98
54	Conclude	12/23/98	12/23/98



Program Schedule Summary (FIGURE 5)

Date: 8/16/94;11:20 am

Table 2 Program Billing Milestones

No.	Date	Brief Description
1	Aug. 15 94	Submit draft program plan
2	Oct. 15 94	"Submit description of ops & performance models"
3	Nov. 15 94	Submit test objective definitions
4	Jan. 03 95	Submit cold flow pier support design requirements
5	Jan. 31 95	Draft test plan established
6	Feb. 28 95	Submit draft report - Basic Phase
7	Apr. 15 95	Prop. module design review(50% complete)
8	Jun. 30 95	Submit propulsion module design drawings
9	Aug. 30 95	Complete phase 1 ops & performance prediction
10	Oct. 31 95	Ship propulsion module to MSFC
11	Nov. 30 95	Draft test sequence 1 test objectives draft report
12	Jan. 03 96	Submit Phase 1 draft final report
13	Jan. 31 96	Complete 20% test sequence 1 objectives
14	Feb. 28 96	Tank design review (50% design complete)
15	Mar 30 96	Complete 80% test sequence 1 objectives
16	Apr. 30 96	Test sequence 1 data review
17	Jun. 30 96	Submit tank module design data book
18	Aug. 30 96	Test sequence 1 extrapolation complete
19	Sept. 30 96	Ship LH2/LO2 tank module to MSFC
20	Nov. 15 96	Submit system definition/requirements update
21	Jan. 03 97	Submit Phase 2 draft final report
22	Feb. 28 97	Ship subsystems module to MSFC
23	Apr. 30 97	Complete 20% test sequence 2 objectives
24	May 30 97	Submit AETF thrust structure design
25	Jun. 30 97	Complete 80% test sequence 2 objectives
26	Jul. 30 97	AETF/IPTD integration design complete
27	Aug. 30 97	Test sequence 2 data review
28	Oct. 30 97	Submit model validation draft report
29	Nov. 30 97	Test sequence 2 extrapolation completed
30	Jan. 03 98	Submit Phase 3 draft final report
31	Feb. 28 98	Ship AETF integration hardware to MSFC
32	May 15 98	Submit test sequence 3 test objectives draft report
33	Jul. 30 98	Complete 20% test sequence 3 objectives
34	Sept. 15 98	Complete 60% test sequence 3 objectives
35	Oct. 30 98	Complete 80% test sequence 3 objectives
36	Nov. 30 98	Test sequence 3 data review
37	Dec. 20 98	Final program review & report submittal

5. TASK APPROACH

The overall program approach discussed in Section 4 has been used by the task team leaders to establish individual task approaches required to satisfy the program objectives in Section 3. The following is a overview methods and issues associated with each of these tasks. The schedule of activities of each task and associated sub tasks is presented in Attachment 1.

5.1 TASK 1, TEST REQUIREMENTS AND PLANS APPROACH

NASA and Rockwell personnel working together as a team will jointly satisfy this responsibility. Task 1 is subdivided into three sub tasks;

- Task 1.1, Identify System Improvement Needs
- Task 1.2, Define Test Objectives
- Task 1.3, Establish Design Requirements, And Prepare Test Plans And Procedures

Figure 6 shows the Sub Tasks in relation to Task 1.0 and Figure 7 shows the task flow.

A team, Program Planning Team (PPT), with representation from both NASA and Rockwell and chaired by Rockwell will be established to perform tasks 1.1, 1.2 and 1.3 with the exception of developing test procedures. Membership for the "Program Planning Team" is shown on Table 3. The basic team membership will be constant for each of the three tasks although minor adjustments may be necessary to accommodate the different objectives of each task. Preparation of test procedures requires great detail, will continue for much of the program and can not be efficiently developed by a planning team. Test procedures will be developed by Rockwell with continual coordination with MSFC test personnel.

Test requirements and plans will be addressed for the entire program during phase 0. However, additional planning activities are scheduled to occur at approximately twelve month intervals through the remainder of the program to accommodate results from parallel activities: 1) technology activities; 2) SSTO program studies and redirection; 3) and significant findings from the NRA 8-11 TA1a program. The team will function for the additional planning activities to be conducted at approximately twelve month intervals.

5.2 TASK 2, IPTD ASSEMBLY AND OPERATION

Based on Task 1 test objectives and data requirements, this task will design, fabricate/assemble, and operate the IPTD. It is divided into three sub task;

- Task 2.1, Establish IPTD Design
- Task 2.2, Fabricate and Integrate the IPTD
- Task 2.3, Perform Test Operations and Data Acquisition

The majority of the design activity will occur in Phase 0 and 1. Propulsion module fabrication and integration will be performed at the during Phase 1 (March -December, 1995), to support the first test operations sequence in Phase 2 (January - February, 1996). Subsequent task activities will focus on developing the tank modules and engine thrust structure to support integrated tri-propellant system testing in the 1998 time frame. The overall task approach indicating key sub task relationships is shown in Figure 8.

The IPTD design task consists of two efforts: fluid/mechanical design, and propulsion checkout and control system (PCCS) design. These two efforts are highly interactive and are integral to the overall IPTD system design. The IPTD design will be simulated and verified prior to fabrication by using low cost software-in-the-loop rapid prototyping.

The IPTD modules will be fabricated by Rockwell in Task 2.2 and shipped pre-assembled to MSFC similar to the PRTA test article. Test article modifications and facility bridging structure will be fabricated and shipped as kits. MSFC will assemble, install, and modify the IPTD as required and adapt or modify the MSFC facilities to support test operations.

Specific operational procedures developed in Task 2.3 for a test series will be based on the completion of Task 1.3. The basic operation will consist of MSFC establishing connection of facility services to the test article. MSFC and Rockwell will assume primary responsibility for controlling test operations using the PCCS. MFSC will provide redundant control for reliable system safety.

5.3 Task 3, DATA ANALYSIS and UTILIZATION

The overall IPTD objective is to assist development and validation of system requirements associated with achieving SSTO operational and performance goals. Figure 3 shows how Task 3 supports this overall objective. This task is divided into the following sub tasks;

- Task 3.1, Develop and Update Math Models and Procedures
- Task 3.2, Extrapolate Data to Operational SSTO Design
- Task 3.3, Develop / Update SSTO Propulsion Requirements

Figure 9 shows the interrelationship of these sub tasks and key elements within Task 3, and other IPTD program tasks. As indicated by Figure 9, Task 3 adapts and augments models and data bases needed to support the following activities; IPTD requirements development, trade study implementation, full scale SSTO system requirements development, and estimation of full-scale SSTO operations timelines and costs.

5.4 TASK 4, PROJECT MANAGEMENT

This task provides management efforts required to direct all program elements and tasks and coordinates preparation and delivery of program products. Included in this task are activities such as program planning, tracking, and measurement of program milestones to funding expenditures. Microsoft Project will be the primary tool for scheduling and tracking task assignments.

Products of the task include monthly status reports with cost and schedule updates as well as descriptions of significant accomplishments. The NASA and Rockwell principal investigator will be primarily responsible to develop these reports for each respective organization based on task team leader inputs. The monthly status reports are due the first Wednesday of each month starting September, 1994. Due to the integrated management nature of this task, it has not been divided into sub tasks as in the three previous tasks.

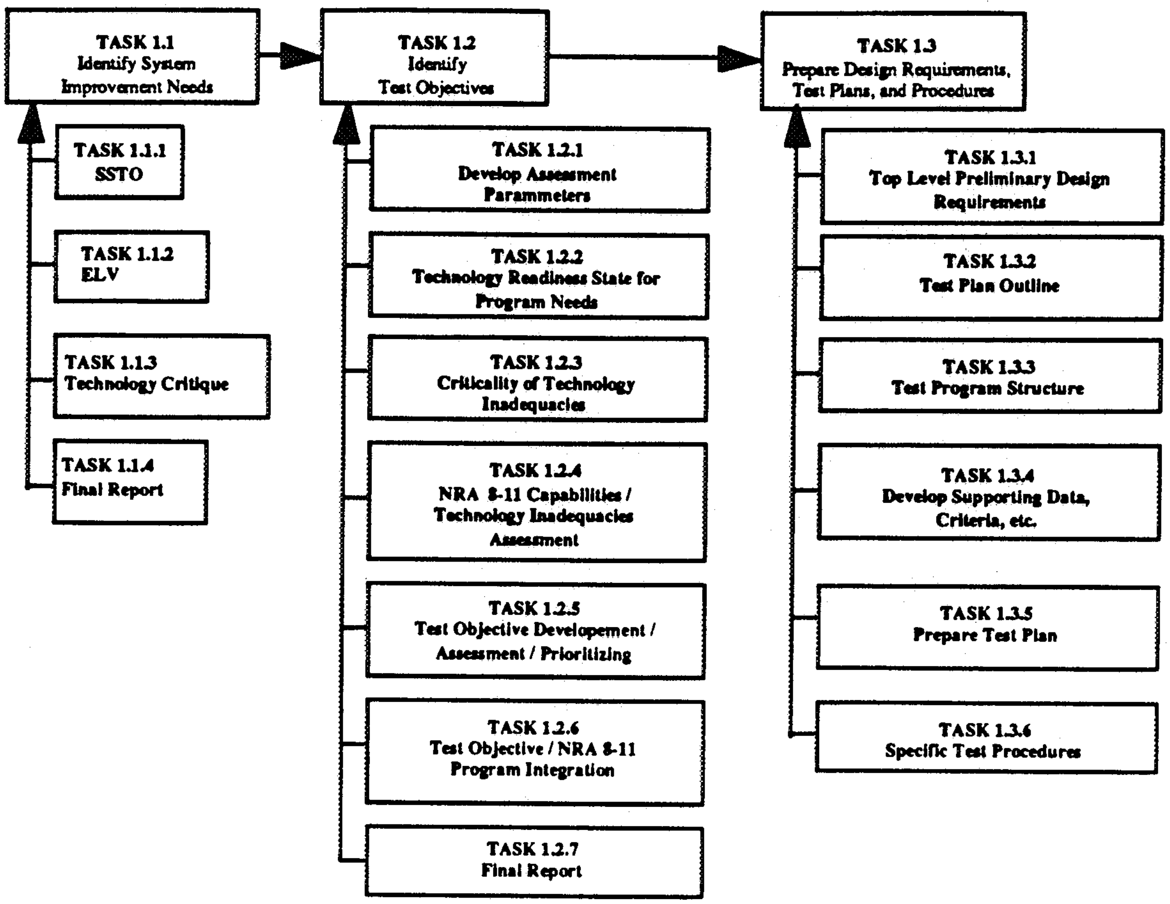


Figure 6 Task 1 Sub Task Identification

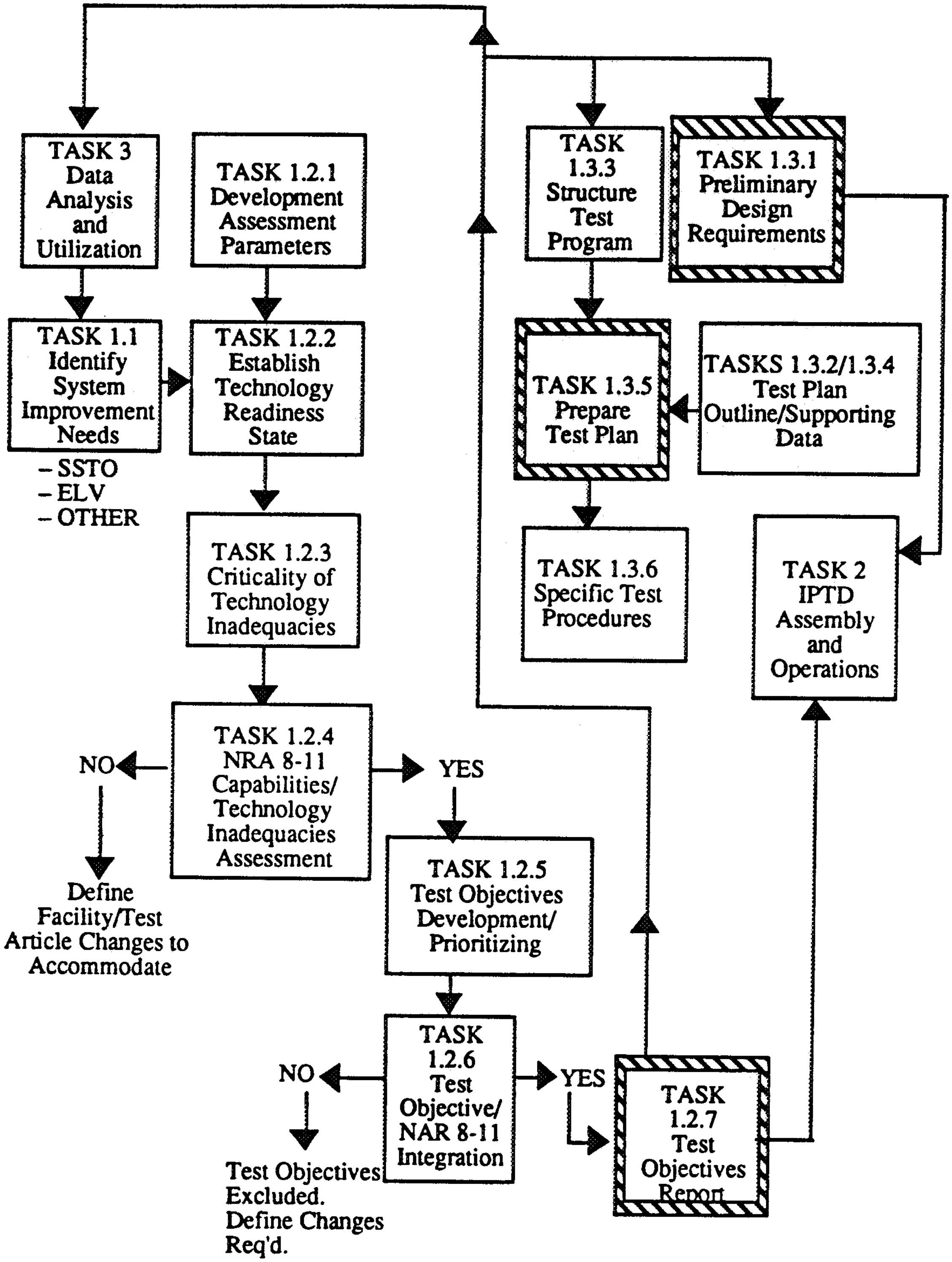


Figure 7 Task 1 Flow

Table 3 Program Planning Team Organization

ORGANIZATION / TASK	TASK 1.1	TASK 1.2	TASK 1.3
Task Leaders			
RI-Huntsville: Charles Wood	√	√	√
MSFC: Mark Fisher (EP-22)	√	√	√
RI-Downey: Propulsion Systems	√	√	√
RI-Downey: Operations Modeling	√	√	√
MSFC: Operations/Propulsion Modeling	√	√	√
KSC: Operations	√	√	√
LERC: Propulsion Technology		√	
MSFC: Propulsion Test			√
RI-Huntsville: Propulsion Operations		√	√
RI-Downey: Propulsion Avionics/Controls/Automation	√	√	√
MSFC: Propulsion Avionics/Controls/Automation	√	√	√

NOTE: Members will utilize additional resources within respective organization as appropriate.

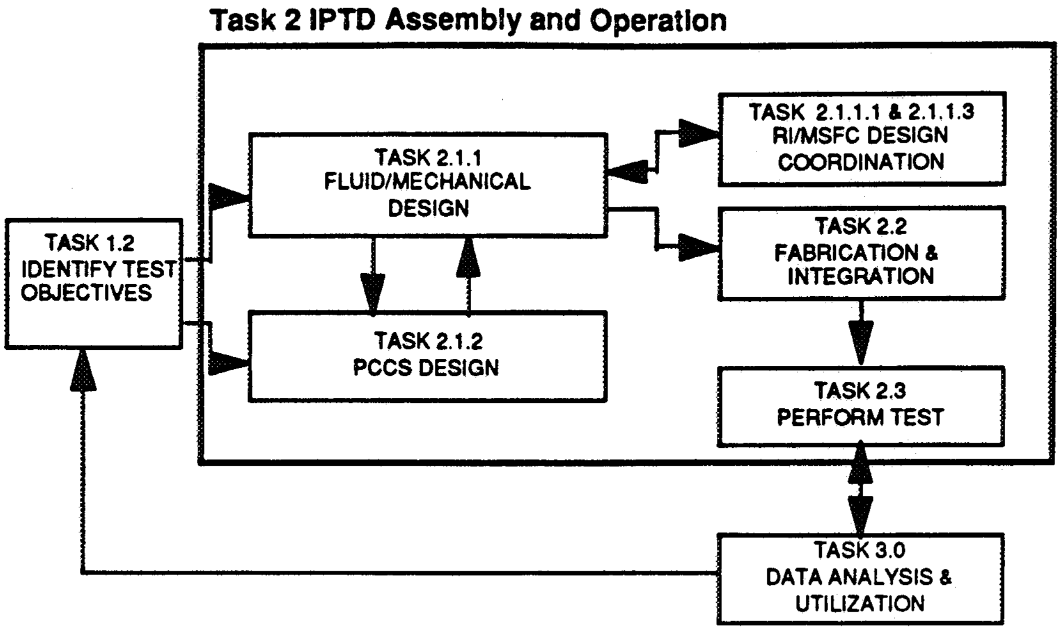


Figure 8, Task 2 Logic Flow

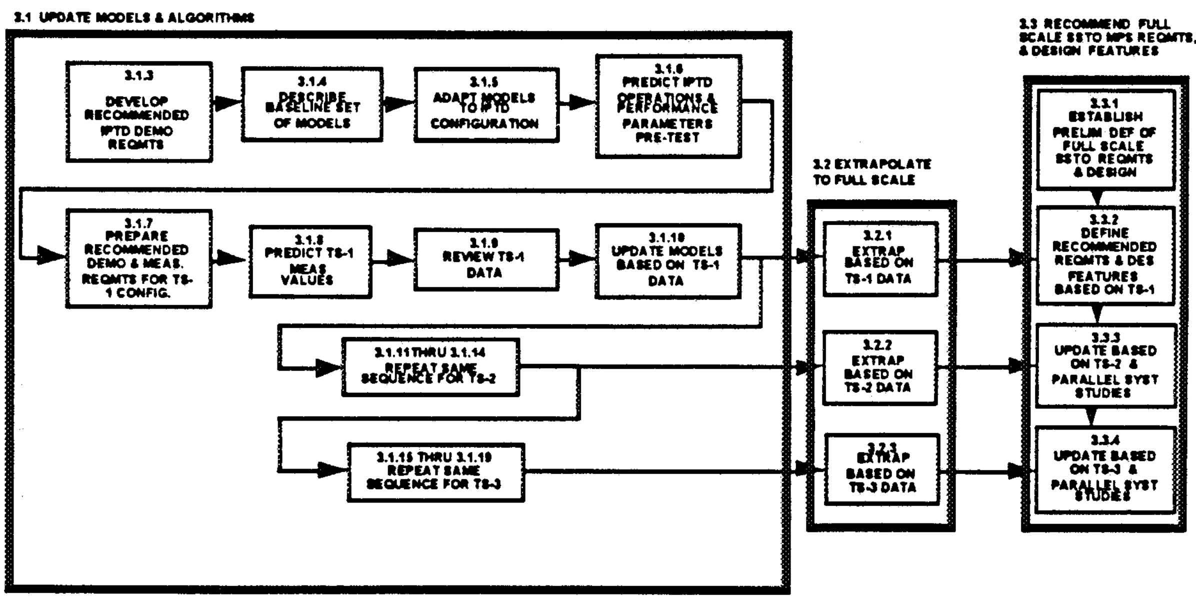


Figure 9, Task 3 Implementation Logic

6. SUB TASK APPROACH

6.1 TASK 1, TEST REQUIREMENTS AND PLANS SUB TASK APPROACH

The following sub task descriptions only address the activities that will be performed during phase 0. However, these tasks will be repeated in three subsequent program phase starting in phase 2. The approach used in subsequent phases are similar to that described in the following;

6.1.1 TASK 1.1, IDENTIFY SYSTEM IMPROVEMENT NEEDS

This task will develop a list of technologies/improvement "needs" which can benefit the SSTO program to most effectively satisfy specific goals. The list will include "needs" relating to performance, safety, operability and cost.

A list of both published and unpublished documents relating to the SSTO program will be compiled and reviewed for determining characteristics of the propulsion system which must be an integral part of the SSTO program flight and ground hardware. Similarly a list of NASA personnel involved in the SSTO program will be compiled and interviewed to accomplish the same objective. Results from the two activities will be consolidated and then evaluated. The end results are necessary propulsion related "needs" which the SSTO program must contain to satisfy program objectives can be met and the relative importance of identified features. Examples of potential SSTO improvement "Needs" are shown in Table 4.

Activities of Sub Task 1.1 as well as sub tasks 1.2 and 1.3 are structured to support programs other than SSTO. Accordingly, propulsion technology for supporting ELV and generic programs will be identified and evaluated as discussed previously for SSTO. A letter to each ELV manufacturer will request technology needs identification and discussions will be initiated as appropriate. Relative to generic technology identification, inputs from the technical staffs of NASA and Rockwell will be obtained as will critical inputs from the STS data base. SSTO technology objectives are highest priority and will be addressed accordingly.

The release of preliminary data is planned to expedite early release of preliminary design requirement needed by tasks 2.1a and 2.1b. A final report will be provided MSFC for approval in Mid October 1994.Task 1.1 includes the following sub tasks;

Task 1.1.1, Define SSTO System Needs
Document and Verbal Review

Start: Aug. 15, 1994
Complete: Sept. 16,1994
Assignment: RI-HSV -60hrs; C. Wood, J. Baker
RI-DNY -20hrs; TBD
NASA,MSFC -50hrs; M. Fisher, H. Campbell; TBD

Task 1.1.2 Define ELV System Needs
Document and Verbal Review

Start: Aug. 15, 1994
Complete: Sept. 9,1994
Assignment: RI-HSV -16hrs; C. Wood
NASA,MSFC -21hrs; M. Fisher

Task 1.1.3, <u>Technology Critique</u>
NASA / Industry product team evaluate critical technologies for incorporation into IPTD program

Start: Aug. 22, 1994
Complete: Sept. 15,1994
Assignment: RI-HSV -18hrs; J. Baker
RI-DNY -16hrs; TBD
NASA,MSFC -21hrs; M. Fisher, TBD

Task 1.1.4, <u>Produce Task Interim/Final Reports</u>
Consolidate Results and Prepare Report

Start: Sept. 19, 1994
Complete: Oct. 15,1994
Assignment: RI-HSV -20hrs; C. Wood, J. Baker
RI-DNY -20hrs; TBD
NASA,MSFC -40hrs; M. Fisher

6.1.2 TASK 1.2 IDENTIFY TEST OBJECTIVES

This task will define test objectives which this program and the resulting test plan will be structured to satisfy. Test objectives are to include technologies for propulsion components, propulsion system ,propulsion/vehicle integration, and propulsion system checkout and control. The program will also address issues relating to performance, safety, operations and cost management. Figure 10 illustrates the test objective selection process.

Technology "needs" established under Sub Task 1.1 for SSTO and other programs will be consolidated and evaluated to determine specific test objectives which can and can not be satisfied in the NRA 8-11 TA 1b. Propulsion technology readiness "state" will be determined for each Task 1.1 identified "need"; specific inadequacies for each ":need" will be defined; capabilities for NRA program 8-11 TA 1b as planned/conceived to satisfy each specific inadequacy will be established; and a list of test objectives will be developed.

Assessment of the list of test objectives from the standpoint of technical importance, cost to obtain necessary information, test and reconfiguration times to acquire the data are essential and will be determined. The result is a prioritized list of test objectives. A preliminary list of parameters for evaluating needs/test objectives is shown in Table 5. Test objectives will then be integrated into the planned five phased NRA 8-11 TA 1b program to facilitate efficient conduct of the approximate four year program. A report will be issued at the conclusion of this effort, November 15, 1994.

Important vehicle propulsion system "needs" identified for the SSTO program which cannot be readily accommodated in the NRA 8-11 TA-1b program will be identified early and reported to management along with the consequences of modifying the program to accommodate excluded "needs". Specific prioritized test objectives which are not planned for inclusion will be reported similarly. Task 1.2 includes the following sub tasks;

1.2.1 Develop Assessment Parameters

Start: Aug. 15, 1994
Complete: Sept. 7,1994
Assignment: RI-HSV -8hrs; C. Wood
RI-DNY -8hrs; C. TBD
NASA,MSFC -8hrs; M. Fisher, H. Campbell

1.2.2 Technology Readiness State For Program "Needs"

Start: Sept. 7, 1994
Complete: Sept. 22,1994
Assignment: RI-HSV -40hrs; C. Wood, J. Baker
RI-DNY -90hrs; TBD
NASA,MSFC -80hrs; M. Fisher, TBD

1.2.3 Criticality Of Technology Inadequacies

Start: Sept. 19, 1994
Complete: Oct. 4,1994
Assignment: RI-HSV -8hrs; C. Wood, TBD
RI-DNY -8hrs; TBD
NASA,MSFC -12hrs; TBD

1.2.4 <u>NRA 8-11 Ta 1b Capabilities / Technology Inadequacies Assessment</u>

Start: Sept. 26, 1994
Complete: Oct. 17,1994
Assignment: RI-HSV -26hrs; C. Wood, J. Baker
RI-DNY -26hrs; TBD
NASA,MSFC -24hrs; TBD

1.2.5 <u>Test Objective Development / Assessment / Prioritizing</u>

Start: Oct. 6, 1994
Complete: Nov. 4,1994
Assignment: RI-HSV -50hrs; C. Wood, L. Sisson
RI-DNY -80hrs; TBD
NASA,MSFC -100hrs; M. Fisher, TBD

1.2.6 <u>Test Objective / NRA 8-11 Ta 1b Program Integration</u>

Start: Oct. 20, 1994
Complete: Nov. 8,1994
Assignment: RI-HSV -40hrs; J. Baker, L. Sisson
RI-DNY -60hrs; TBD
NASA,MSFC -80hrs; M. Fisher, TBD

1.2.7 <u>Report Preparation</u>

Start: Oct. 11, 1994
Complete: Nov. 15,1994
Assignment: RI-HSV -30hrs; C. Wood, J. Baker
RI-DNY -30hrs; TBD
NASA,MSFC -80hrs; M. Fisher, TBD

6.1.3 TASK 1.3 PREPARE DESIGN REQUIREMENTS, TEST PLANS, AND PROCEDURES

While the primary objective of this task is development of test plans and procedures, initial efforts will be devoted to developing top level preliminary design requirements necessary for preliminary design activity under Task 2 to commence. Results from early assessments, conducted under Task 1.2, of the "needs" for SSTO and other applications will serve as the basis for developing top level requirements. Design requirements will be finalized later in the program by Task 2 activities in an iterative process as specific test objectives from Task 1.2 are generated and as Task 2 design activity is completed.

This task, exclusive of developing test procedures, will be performed by the program planning team shown on Table CWW002. Test procedures will be developed outside of the team structure by joint Rockwell and MSFC activity. Test procedures may change from test to test and development cannot be effectively initiated until much later in the program when hardware has been designed, hardware integration activities are completed and individual test objectives are known.

Activities for developing the program test plan will start approximately mid October 1994 when task 1.2 provides sufficient visibility relative to test objective priority and supporting data on cost, time for testing, etc. A test plan document outline will be developed. The prioritized test objectives, their selection and preliminary program structuring conducted by Task 1.2 will be reviewed and actual program structuring finalized with stronger emphasis from test personnel who will be conducting testing. Activity to define input data consistent with the test plan outline will be initiated (instrumentation, data processing, photography coverage, controls including emergency control provisions, redlines, and etc.). The test plan will be approved by appropriate Rockwell and MSFC management including management with SSTO affiliation.

The test plan will be structured to span the total approximately four year program. It is to be a living document with three planned updates at approximately twelve month intervals. Table 6 illustrates the wide range of test activity reflected in the test plan. Task 1.3 includes the following sub tasks;

1.3.1 Top Level Preliminary Design Requirements

Start: Aug. 24, 1994
Complete: Sept. 7,1994
Assignment: RI-HSV -80hrs; J. Honeycutt, J. Baker, C. Wood
RI-DNY -65hrs; TBD
NASA,MSFC -60hrs; M. Fisher, TBD

1.3.2 Test Plan Outline

Start: Oct. 3, 1994
Complete: Oct. 17,1994
Assignment: RI-HSV -12hrs; L. Sisson
RI-DNY -4hrs; TBD
NASA,MSFC -8hrs; TBD

1.3.3 Test Program Structuring

Start: Nov. 14, 1994
Complete: Dec. 9,1994
Assignment: RI-HSV -35hrs; C. Wood, L. Sisson
RI-DNY -25hrs; TBD
NASA,MSFC -60hrs; M. Fisher, TBD

1.3.4 Develop Supporting Data and Criteria

Start: Oct. 17, 1994
Complete: Jan. 1,1995
Assignment: RI-HSV -70hrs; J. Honeycutt, J. Baker, L. Sisson
RI-DNY -40hrs; TBD
NASA,MSFC -100hrs; M. Fisher, TBD

1.3.5 Prepare Test Plan

Start: Dec. 5, 1994
Complete: Jan. 31,1995
Assignment: RI-HSV -70hrs; J. Baker, L. Sisson
RI-DNY -30hrs; TBD
NASA,MSFC -70hrs; TBD

1.3.6 PrepareTest Procedures

Start: Oct. 1, 1995
Complete: Continues
Assignment: RI-HSV -TBDhrs; L. Sisson
RI-DNY -TBDhrs; TBD Note: Hours budgeted in program Phase 1.
NASA,MSFC -TBDhrs; TBD

Table 4 Example of SSTO Improvement "Needs"

SSTO Goal	Issue	Potential Solution (Improvement)	Issue With Potential Solution	Data Required To Resolve	Why IPTD is Best Data Source	Test Phase	Design Requirement for
Reduced dry weight to achieve required performance	Tanks storing low-density, high-performance (Isp) propellant are large and therefore heavy	Add HC propellant	Adds complexity	Operations cost data and time lines	Scaleable to operational vehicle	3	Tanks, GSE, MPS, engines
Reduced operations time/cost	Recirculation system is complex with costly components. Takes too long to check out with many failure modes	Overboard bleed or passive propellant conditioning to replace recirculation system	Integrated system never empirically validated; no associated operations data available	Performance and operational data for simplified system (s)	Representation of full system; IPTD similar to flight size	2	MPS, engines
	System require complete checkout because health may be unknown	Maintenance on demand	IVHM has not been empirically verified	End-to-end verification of IVHM	IPTD performs system autonomous checkout and loading	All	Tanks, GSE, MPS, engine
	Labor intensive manual leak detection methods.	Advanced automated leak detection methods	Integrated system never empirically validated	End-to-end verification of advanced concept(s)	Representation of full system	2	MPS
	Complex pneumatic system requires checkout, which may be difficult to automate	EMAs replace pneumatic valve actuators	Integrated system never empirically validated	End-to-end verification of EMA system; operations data	Representation of full system	2	Cryogenic valves, power and control
	Major source of STS MPS failure is sensor related	Increase sensor reliability and software	Sensor technology lagging smart sensor software	Validation of reliability, hardware and software	Complete system validation requires comparisons to other sensor data	All	Sensor suite, control system
	Engine controls separate from vehicle and GSE control, leads to incompatible interfaces (e.g., EIU)	Merge vehicle and engine controllers into one controlling system	Concept has not been developed	Validated engine vehicle controlling system	Full propulsion system operating environment	2, 3	GSE, MPS, engine

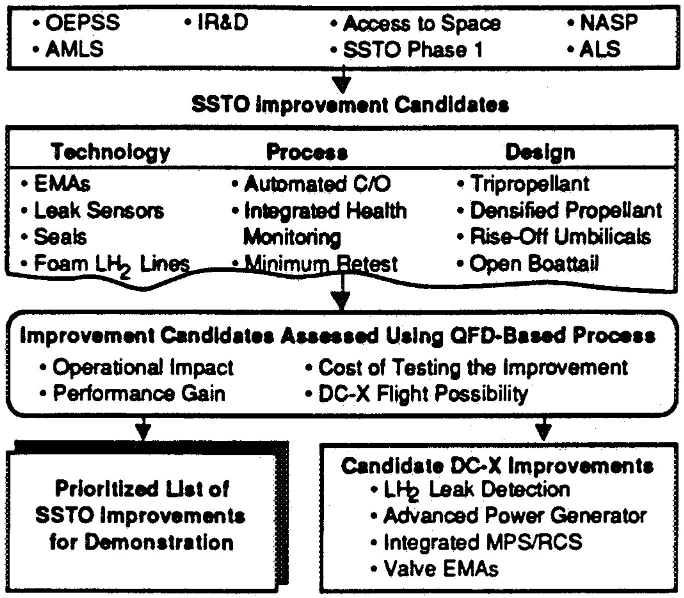


Figure 10, Program Tests Improvements With Best Benefits / Costs

Table 5 Evaluation Process For Judging SSTO Program "Needs"/Objectives (Preliminary)

1. Technologies involved in each SSTO "need" determined from Task 1.1
2. Technology maturity of each. Specifically what is inadequate?
3. Criticality of inadequate technology for SSTO mission accomplishment.
4. Relate inadequate technology to ground or flight, cost, operations, safety, performance.
5. Is inadequate technology being resolved elsewhere in a timely manner?
6. Can the inadequate technology be satisfied by NRA 8-11 TA 1b? Is the obtained results representative for KSC or can results be related to the KSC environment by modeling techniques?
7. If inadequate technology is resolved on NRA 8-11 TA 1b, is it a major "driver" on the program as conceived relative to cost, facility, modifications, time to perform test, etc.?
8. If task can be performed on NRA 8-11 what are specific test objectives?
9. If task cannot be effectively performed, scope physical changes required to accomplish satisfactorily.

Table 6 Test Plan Reflects a Wide Range of IPDT Activities

Phase	Core Program Test Objective	Test Activity
2	Demonstrate automated test and checkout system; verify rapid prototyping process	Develop hardware and software simulation system
3	• Demonstrate automated loading • Passive propellant conditioning • Operations data for LO_2/LH_2 system with LO_2 forward	• LO_2 tanking with LN_2 • LH_2 tanking with LH_2 • LN_2/LH_2 tanking
3	• Demonstrate propellant conditioning with bleeds • Operations data with LO_2 aft	• LH_2 tanking with LH_2 • Evaluate bleed preconditioning
3	• Operations data for tripropellant system • Demonstrate EMA valve control • Repeatability/accuracy of leak detection system	• RP-1 tanking with H_20 • $LN_2/LH_2/H_20$ tanking
3	• Integrated MPS/OMS/RCS operations data • Provide operations data rise-off umbilical system	• Install and test O_2/H_2 OMS and RCS • Demonstrate rise-off umbilical
3	Operations data for flight-type TPS	Add flight-type TPS to tanks
4	• Total propellant system operations data • Operations data for open boattail	• LO_2/LH_2/RP-1 tanking and integrated system/engineering
4	• Operations data for closed boattail	• Repeat prior open boattail test
4	• Demonstrate integration and operations data	• Engine Firings
4	• Assess TVC EMA operations • Evaluate flight-type tanks	• Test EMA for engine gimbaling • Replace test tanks with flight type

6.2 TASK 2 , IPTD ASSEMBLY AND OPERATION SUB TASK APPROACH

6.2.1 TASK 2.1, ESTABLISH IPTD DESIGN

TASK 2.1.1, Fluid and Mechanical Design

The IPTD will be configured with full-scale components and fluid lines using spare Shuttle hardware to the maximum extent possible. The design will allow incremental upgrades to flight type components, advanced sensor developments, and other emerging technologies. The IPTD will also be designed to be compatible with MSFC facilities both at the MSFC LH_2 Cold Flow Facility (HCF) and Advanced Engine Test Facility (AETF).

This sub task is performed from phase 0 through phase 3. This design task is not performed during phase 4 since the effort during this phase is focused on integrating the IPTD within the AETF-2 and conducting engine/system integrated tests. Subtasks 2.1.1.1 through 2.1.1.11 occur in phase 0, and sub tasks 2.1.1.12 through 2.1.1.17 occur in phase 1. Outyear task activities are summarized in sub tasks 2.1.1.18 and 2.1.1.19 for phases 2 and 3 respectively.

TASK 2.1.1.1 RI/MSFC design coordination

Prepare and update plans of action, schedules and cost estimates. Coordinate design activities and facilitate information transfer between RI and MSFC personnel for all task efforts. Prepare briefings and program status reports as required
Start 8-1-94, end 2-28-95

J. Honeycutt - 440 hrs
J. Rogers - 160 hrs
H. Leblanc - 200 hrs
R. Burbank (MFSC) - 400 hrs
TBD (MSFC) - 200 hrs

Task 2.1.1.2 - Preliminary IPTD design

Establish basic structure and system design approach from Task 1.3 requirements.
Start 10-1-94, end 11-30-94

S. Petrilla - 240 hrs.
H. Leblanc - 160 hrs
J. Rogers - 80 hrs
R. Burbank (MSFC) - 160 hrs

Task 2.1.1.3 - Design/coordinate HCF pier supports

Provide designs and requirements for MFSC installed IPTD supports.
Start 10-1-95, end 1-3-95

J. Rogers - 40 hrs
TBD Designer RI/HSV - 80
TDB Designer (MFSC) - 200 hrs

Task 2.1.1.4 Preliminary propellant tank design

Detail propellant tank configuration and secure fabrication bid costs
Start 10-1-94, end 10-31-94

TBD Designer RI/DNY - 60
J. Rogers - 60 hrs
S. Petrilla - 40 hrs
D. Meyers - 20 hrs

Task 2.1.1.5 Preliminary Propulsion Module Design

Provide basic structure support design for the prop module.
Start 11-1-94, end 11-30-94

TBD Designer RI/DNY - 160
J. Rogers - 40 hrs
D. Meyers - 20 hrs
H. Leblanc - 20 hrs

Task 2.1.1.6 - Procure Propulsion Module Instrumentation

Research and acquire long lead time sensors and instruments, expected expenditure-$25K
Start 11-1-94, end 1-31-95

T. Tran - 60

Task 2.1.1.7 - Design HCF pier support bridging beams

Design interconnection beam structure between the large footprint piers and the small footprint IPTD. Order material $5K
Start 12-1-94, end 1-3-94

TBD Designer RI/DNY - 80

Task 2.1.1.8 - Design HCF propulsion module integration mods

Design modifications to the HCF to integrate with the IPTD
Start 12-1-94, end 3-31-95

J. Rogers - 80 hrs
TBD Designer RI/HSV - 40
S. Petrilla - 80 hrs.
R. Burbank (MSFC) - 320 hrs
TBD Designer (MFSC) - 600 hrs

Task 2.1.1.9 - Design IPTD lifting and rotation fixtures

Design fixtures and order material, $5K
Start 1-3-95, end 1-31-95

TBD Designer RI/DNY - 80
J. Rogers - 20 hrs

Task 2.1.1.10 - Design propulsion module haz-gas detection systems

Design and procure systems to detect LH2 leakage. $10K
Start 2-1-95, end 2-28-95

J. Rogers - 80 hrs
S. Petrilla - 40 hrs.
H. Leblanc - 40 hrs

Task 2.1.1.11 Propulsion module design review

Review all available design information and compare to requirements of Task 1. Report findings to MFSC 4-15-95
Start 2-1-95, end 2-28-95

J. Rogers - 40 hrs
S. Petrilla - 40 hrs.
H. Leblanc - 40 hrs
T. Gaynor - 40 hrs
J. Honeycutt - 40 hrs
R. Burbank (MFSC) - 40 hrs

Task 2.1.1.12 RI/MSFC design coordination

Prepare and update plans of action, schedules and cost estimates. Coordinate design activities and facilitate information transfer between RI and MSFC personnel for all task efforts. Prepare briefings and program status reports as required
Start 3-1-95, end 6-30-95

J. Honeycutt - 80 hrs
H. Leblanc - 80 hrs
R. Burbank (MFSC) - 80 hrs

Task 2.1.1.13 Complete propulsion module structure design

Finalize design and order material, $10K
Start 3-1-95, end 3-31-95

TBD Designer RI/DNY - 200
J. Rogers - 80 hrs
H. Leblanc - 40 hrs

Task 2.1.1.14 Design propulsion module plumbing and brackets

Finalize fluid system design and order material, $12K
Start 3-1-95, end 4-30-95

TBD Fluid designer RI/DNY -180
J. Rogers - 160 hrs
S. Petrilla - 120 hrs.
H. Leblanc - 120 hrs

Task 2.1.1.15 Design propulsion module instrumentation systems

Design sensor installations, connector configurations, and cable routing and patch systems.
Start 3-15-95, end 6-30-95

J. Rogers - 120 hrs
S. Petrilla - 60 hrs.
T. Tran - 220 hrs

Task 2.1.1.16 Procure propulsion module instrumentation

Research and obtain remaining sensors. Expected expenditure, $25K
Start 4-1-95, end 5-31-95

T. Tran - 60 hrs

Task 2.1.1.17 Design propulsion module fire-ex system

Design plumbing and spray head support system. Procure hardware; $1K
Start 5-1-95, end 5-31-95

J. Rogers - 80 hrs
R. Burbank (MFSC) - 120 hrs

Task 2.1.1.18 Design modifications to the IPTD to incorporate propellant tanks and control systems.

Start 1-3-96, end 6-30-96

Expected effort:
RI - 2820 hrs
MFSC - TBD hrs

Task 2.1.1.19 Design modifications and upgrades to the IPTD for use on the AETF. Design a 500K lbs thrust structure for the AETF.

Start 1-3-97, end 6-30-97

Expected effort:
RI - 3480 hrs
MSFC - TBD hrs

TASK 2.1.2, Propulsion Checkout and Control System (PCCS)

The PCCS will have two objectives: (1) eliminate manual checkout and the corresponding labor intensive data collection, analysis, and monitoring; and (2) provide a platform that integrates advanced process methodologies to reduce propulsion system development costs. The PCCS will use automated fault-tolerant checkout and autonomous control technologies to enable rapid and cost effective turnaround for the production, test, and operations phases of the IPTD and supporting facilities. Checkout and control is provided for components, subsystem, vehicle, and ground elements.

The PCCS will treat the IPTD as if it were an operational vehicle whose primary goal is to eliminate all manual test and checkout. The PCCS will utilize low cost VME backplane standards with multi-parallel R3000 processors, and supporting I/O and A/D to D/A boards, software will be developed on UNIX based C++ operating systems, and COTS application software (G2, Dataviews, others) will be heavily leveraged. This low cost platform will functionally demonstrate autonomous propulsion checkout and control and firmly establish flight control system requirements for future avionics technology development efforts.

Advanced development processes will also be employed in developing the PCCS. These processes include: Rapid prototyping and concurrent engineering design approaches through geographically distributed analysis design and simulations; utilization of common databases with standardized interfaces for all program phases (design/analysis, simulation, test and operations); and incorporation of fault modeling and real-time FMEA fault trees as a foundation for the checkout and control expert systems.

PCCS development is partitioned into four major efforts: 1- Development and updates to the PCCS simulation infrastructure; 2 - Development and updates of component and system models; 3 - IPTD Failure Modes Effects and Analysis and interactive fault protection and IPTD fluid system design optimization; and 4 - Development and implementation of the PCCS command and control system.

This sub task is performed in all program phases starting with developing the IPTD check-out and control requirements in phase 0, and culminating in the functional demonstration of the PCCS during the integrated engine/system hot fire test operations (phase 4). Sub tasks 2.1.2.1 through 2.1.2.5 occur in phase 0, and sub tasks 2.1.2.6 through 2.1.2.15 occur in phase 1. Out -year activities for phase 2 through 4 are summarized in sub task 2.1.2.16 through 2.1.2.18 respectively.

Task 2.1.2.1 - RI/NASA PCCS Design Coordination

Prepare and update plans of action, schedules and cost estimates. Coordinate design activities and facilitate information transfer between RI and MSFC personnel for all task efforts. Prepare briefings and program status reports as required. Team PCCS will support interim Phase 0 PCCS technical review at Downey (01-15-95).
Start 07-15-94, end 2-28-95

Teeter/Gormley - 120 hrs
S. Wise - 40 hrs
TBD (MSFC-Sim Lab) - 100 hrs
TBD (MSFC-Controls) - 100 hrs

Task 2.1.2.2 - Preliminary PCCS Simulation and Control Design

Support Task 1 objectives and requirements definitions to drive PCCS development. Initiate PCCS architecture definitions: Design and evaluation of candidate architectures; Functional allocation of chosen architecture; Identification of usable test stand assets; and System level hardware/software definitions. Downey PCCS will travel to MSFC to identify usable assets and review/update PCCS preliminary architecture.
Start 09-1-94, end 12-15-94

Teeter/Gormley - 40 hrs
S. Petrilla - 40 hrs
S. Wise - 260 hrs
J. Jones (RI/HSV) - 100 hrs
J. Zakrajsek (LeRC) - 100 hrs
A. Hines (ARC) - 100 hrs
TBD (MSFC-Sim Lab) - 100 hrs
TBD (MSFC-Controls) - 100 hrs

Task 2.1.2.3 - Develop Propulsion Module Functional System Model

Establish a foundation for end-to-end PCCS analysis tools (simulations, common databases, CATIA drawings, fluid analysis tools, FMEA analysis tools, fault block diagrams, control algorithms, etc). Initiate functional model development at the system, subsystem, and component levels. Identify preliminary functions, controls, and sensors. Capture the connectivity and components of the system that will be used for failure analysis. Develop a high functional level simulation in the beginning and add detail as the design progresses.
Start 12-5-94, end 02-28-95

M. Holthaus - 100 hrs
S. Petrilla - 120 hrs
S. Wise - 260 hrs
A. Hines (ARC) - 100 hrs
TDB (MSFC-Sim Lab) - 200 hrs

Task 2.1.2.4 - Establish Real-Time Connections Between RI and NASA Partners

Establish data link connections between RI-DNY, RI-HSV, MSFC-MAST, LeRC and ARC. Provide capability for PCCS partners to interface with real-time PCCS simulations and provide mechanism for partners to electronically add their respective technology elements into system simulations.
Start 01-04-95, end 02-28-95
S. Wise - 100 hrs
J. Jones - 40 hrs
J. Zakrajsek (LeRC) - 40 hrs
A. Hines (ARC) - 40 hrs
TBD (MSFC-Sim Lab) - 100 hrs

Task 2.1.2.5 - Document Phase 0 PCCS Results.

Provide end of phase final documentation.
Start 02-01-95, end 02-28-95

Teeter/Gormley - 40 hrs
TBD (MSFC - Sim Lab) - 20 hrs
TBD (MSFC - Controls) - 20 hrs

Task 2.1.2.6 - RI/NASA PCCS Design Coordination

Prepare and update plans of action, schedules and cost estimates. Coordinate design activities and facilitate information transfer between RI and MSFC personnel for all task efforts. Prepare briefings and program status reports as required
Start 3-01-95, end 12-31-95

Teeter/Gormley - 80 hrs
S. Wise - 80 hrs
TBD (MSFC-Sim Lab) - 100 hrs
TBD (MSFC-Controls) - 100 hrs

Task 2.1.2.7 - Assemble Top Level Engine Functional Control Requirements

Interface with MSFC-HSL and derive/obtain tri-propellant engine control requirements Early requirements needed to properly scope PCCS simulation and control architecture to achieve downstream common IPTD/engine control.
Start 03-01-95, end 04-01-95

S. Wise - 20 hrs
J. Jones (RI/HSV) - 40 hrs
TBD (MSFC-HSL) - 100 hrs

Task 2.1.2.8 - Define Requirements for Partitioned Controllers

Coordinate and develop requirements for localized intelligent smart sensor/controller (LeRC) and real-time fault trees and digraph models (ARC) to optimally scope PCCS architecture for Phase 2 implementation. Smart sensor/controller algorithms will be functionally demonstrated on embedded VME processor but hooks will be provided to migrate/investigate smart algorithms integrated on smart sensor micro-processors.
Start 04-01-95, end 05-01-95

M. Holthaus - 30 hrs
S. Wise - 30 hrs
A. Hines (ARC) - 80 hrs
J. Zakrajsek (LeRC) - 80 hrs

Task 2.1.2.9 - Identify HCF/PCCS Controls and Instrumentation Interface Requirements

Identify current and planned HCF controls and instrumentation interfaces and incorporate into PCCS design requirements. Provide preliminary PCCS interface definitions to MSFC HCF Controls Lab
Start 04-01-95, end 05-01-95

S. Wise - 30 hrs
J. Jones (RI/HSV) - 30 hrs
TBD (MSFC-HSL) - 50 hrs

Task 2.1.2.10 - Update PCCS Simulation and Control System Design

Update candidate architecture design based on preliminary and final propulsion module designs, HCF, and engine control requirements. Establish functional allocation of architecture; reserve usable MSFC test stand assets; and identify system level hardware/software definitions. Design PCCS hardware elements: Interface elements; signal conditioning and I/O elements; communication interfaces; test stand cabling; and instrumentation. Design PCCS software elements: Configuration of processing nodes; communication modules, I/O modules; smart sensor interfaces; AI/ES and conventional control laws. Document system configuration and interface requirements and establish data storage formats for component bench top tests. Team PCCS to review and update system specification at MSFC on 06-05-95.
Start 03-01-95, end 06-05-95

Teeter/Gormley - 40 hrs
S. Petrilla - 40 hrs
S. Wise - 300 hrs
J. Jones (RI/HSV) - 50 hrs
TBD (MSFC-Sim Lab) - 100 hrs
TBD (MSFC-Controls) - 100 hrs

Task 2.1.2.11 - Develop Propulsion Module Component/System Failure Models

Complete Propulsion Module System Functional Simulation and develop failure models at the function, system, subsystem, and component levels. Individual components will be assessed for their failure modes, causes, and individual effects. These component failures will be connected into the system to determine how the effects of one component failure can eventually propagate down stream causing the anomalous operation of a function.
Start 03-01-95, end 05-31-95

M. Holthaus - 400 hrs
S. Petrilla - 100 hrs
S. Wise - 100 hrs
A. Hines (ARC) - 100 hrs
TBD (MSFC-Sim Lab) - 300 hrs

Task 2.1.2.12 - Update Sequence 1 Propulsion Module and HCF Designs

Recommend Propulsion Module and HCF changes in redundancy, automated controls, component and sensor placement to enable automated testing and maintenance by exception. As the design progresses continuous evaluation and feedback will be made to determine if the reliability and safety goals are being satisfied. A trade-off study will be made to justify design changes versus operations cost, reliability, and safety goals.
Start 06-01-95, end 06-31-95

Teeter/Gormley - 50 hrs
S. Petrilla - 50 hrs

Task 2.1.2.13 - Build and Validate Sequence 1 PCCS

Validate control system using the functional and failure system models and fault injection capabilities in the simulation environment. Replace the component models with bench top checkout test data and support propulsion module Downey checkout tests to validate command sequences, control logic, and instrumentation data processing. upon completion of Downey and MSFC-MAST SWIL and HWIL validation, MAST PCCS will be transferred to HCF Block House.
Start 06-01-95, end 10-23-95

Teeter/Gormley - 100 hrs
S. Petrilla - 200 hrs
S. Wise - 600 hrs
TBD (MSFC-Sim Lab) - 300 hrs
TBD (MSFC-Controls) - 300 hrs

Task 2.1.2.14 - Integrate PCCS With HCF Controls/Instrumentation

Integrate PCCS block house user interface with PCCS VME control system and signal conditioners in AETF basement through fiber optic cables. Integrate AETF basement units with Propulsion Module and HCF sensors, components and valves. Functionally demonstrate and verify all valve actuation and response time, control logic, pressure and flow control and sensor data acquisition. RI-Downey will support on-site installation and PCCS check-out with support from RI-HSV and MSFC-HCF. Team PCCS will support Sequence 1 PCCS test readiness review.
Start 11-01-95, end 12-31-95

S. Petrilla - 60 hrs
S. Wise - 300 hrs
J. Jones (RI-HSV) - 60 hrs
TBD (MSFC-Controls) - 300 hrs

Task 2.1.2.15 - Document Phase 1 PCCS Results.

Provide end of Phase 1 final documentation.
Start 11-15-95, end 12-15-95

Teeter/Gormley - 20 hrs
S. Wise - 20 hrs

Task 2.1.2.16 - Phase 2 PCCS Development

Integrate and verify the sensor validation algorithms within the PCCS smart sensor/controller (LeRC/RI) and the real-time fault models/trees (ARC/RI) into the PCCS. Functionally demonstrate and provide Test Sequence 2 Integrated Cold Flow Test Operations autonomous checkout and control. Update the FMEA to reflect engine and propulsion system component interface requirements and initiate Intelligent Electrical Power Distribution and Control (EPD&C) prototype development.
Start 01-03-96, end 12-31-96

Rockwell - 4460 hrs
MSFC - TBD
LeRC - TBD
ARC - TBD

Task 2.1.2.17- Phase 3 PCCS Development

Develop a dedicated controller for valve and component actuation control and health and status reports. Update and validate the sensor validation algorithms, real-time fault trees and intelligent EPD&C controller to include engine interface requirements. Checkout and demonstrate preliminary engine/system control during PCCS and test stand simulation tests using engine controller models provided by TA-1 (a) engine contractor(s).
Start 01-03-97, end 12-31-97

Rockwell - 7800 hrs
MSFC - TBD
LeRC - TBD
ARC - TBD

Task 2.1.2.18 - Phase 4 PCCS Development

Integrate and validate the Integrated Engine/System PCCS (smart sensor/controller with sensor validation algorithms, real-time fault trees, intelligent EPD&C and the valve/component actuation/health controller) during PCCS development, integration and simulation tests. Functionally demonstrate the PCCS during test Sequence 3 integrated engine/system hot fire test operations.
Start 01-03-98, end 12-31-98

Rockwell - 4280 hrs
MSFC - TBD
LeRC - TBD
ARC - TBD

6.2.2 TASK 2.2, IPTD FABRICATION AND INTEGRATION

This task spans all four program phase with the phase 0 activity focusing on collecting existing STS fluid components which will be integrated in the IPTD during phase 1 and 2. Phase 1 Task descriptions are described in sub task 2.2.2 through 2.2.18. Outyear task activities for phase 2 through 4 are summarized in sub task 2.2.19 through 2.2.21 respectively.

Task 2.2.1, Procure Shuttle component hardware
Locate and obtain available spares or test unit hardware from Shuttle or other aerospace programs that could be utilized in an IPTD envisioned by the NRA proposal. Projected misc. costs, $20K.
Start 8-15-94, end 2-28-95

M. Peller - 120 hrs

Task 2.2.2, Coordinate Phase 1 production operations

Coordinate activities between the fabrication specialties at RI and MFSC. Provide and update plans of action and cost estimates. Report and brief progress as required.
Start 3-1-95, end 10-31-95

J. Honeycutt - 240 hrs
H. Leblanc - 160 hrs
J. Rogers - 160 hrs

Task 2.2.3, Fabricate HCF pier support bridging beams

Start 3-1-95, end 3-31-95

D. Myers - 20 hrs
TDB Mech Tech - 140 hrs

Task 2.2.4, Refurbish Shuttle components

Rebuild and functional check acquired spare or test unit components
Start 3-1-95, end 4-30-95

M. Peller - 80 hrs
TDB Fluid Tech - 160 hrs

Task 2.2.5, Fabricate propulsion module structure

Start 4-1-95 end 6-30-95

J. Rogers - 100
D. Myers - 120 hrs
TDB Mech Tech - 540 hrs

Task 2.2.6, Fabricate and integrate HCF facility modifications

Fabricate appropriate IPTD integration hardware in RI DNY. Install piers and plumbing modifications to integrate IPTD at MSFC. Expected MFSC cost, $50K
Start 4-3-95, end 10-30-95

J. Rogers - 100 hrs
TDB Fluid Tech - 140 hrs
R. Burbank - 560 hrs
TBD MFSC Tech - 1280 hrs

Task 2.2.7, Fabricate IPTD lifting and rotation fixtures

Start 4-1-95, end 4-30-95

J. Rogers - 20
D. Myers - 40 hrs
TDB Mech Tech - 180 hrs

Task 2.2.8, Fabricate fluid lines and support brackets

Start 5-15-95, end 7-31-95

J. Rogers - 100
D. Myers - 40 hrs
TDB Mech Tech - 240 hrs
TDB Fluid Tech - 260 hrs

Task 2.2.9 Cryo shock and proof test fluid lines

Start 6-1-95, end 7-31-95

J. Rogers - 40
TDB Fluid Tech - 120 hrs

Task 2.2.10, Insulate fluid lines

SOFI all cryogenic fluid lines except field joints to be integrated at MFSC

Start 7-1-95, end 7-31-95

J. Rogers - 40
R. Jackson - 120

Task 2.2.11, Install fluid lines in propulsion module structure

Start 7-1-95, end 8-30-95

J. Rogers - 120
TDB Fluid Tech - 280 hrs

Task 2.2.12, Fabricate fire-ex system

Install low pressure pluming and spray heads into propulsion module
Start 8-1-95, end 8-30-95

J. Rogers - 20
TDB Fluid Tech - 80 hrs

Task 2.2.13, Install instrumentation and patch systems

Install and connect sensors to the propulsion module systems and route cabling to a common interface location.
Start 8-15-95, end 10-16-95

J. Rogers - 100 hrs
T. Tran - 180 hrs
TBD Elec Tech - 340 hrs

Task 2.2.14, Fabricate/install Haz.-gas detection systems

Start 9-1-95, end 9-30-95

J. Rogers - 40
TBD Fluid Tech - 120 hrs

Task 2.2.15, PCCS functional checkout

Verify operation of active components and sensors with the PCCS
Start 9-15-95, end 10-24-95

J. Rogers - 80
TBD Fluid Tech - 80 hrs
T. Tran - 80 hrs
TBD Elec. Tech - 80 hrs
T. Gormley - 160 hrs
TBD PCCS Engr - 160 hrs

Task 2.2.16, Ship propulsion module

Start 10-24-95, end 10-31-95

J. Rogers - 20 hrs
TBD Mech. Tech - 60 hrs

Task 2.2.17, Integrate propulsion module at HCF

Install propulsion module on the pier supports. Connect HCF fluid systems. Install engine simulator and turbo pump. Connect instrumentation to PCCS.
Start 11-1-95, end 1-3-96

J. Honeycutt - 320 hrs
J. Rogers - 120 hrs
H. Leblanc - 40 hrs
R. Jackson - 80 hrs + $1.5K trip
T. Gormley - 320 hrs
TBD PCCS Eng. - 320 hrs
R. Burbank (MFSC) - 320 hrs
TBD MFSC Eng. - 320 hrs
TBD MFSC Tech - 1600 hrs

Task 2.2.18, Procure components for Phase 2 fabrication

Start 10-1-95, end 11-30-95

M. Peller - 100 hrs

Task 2.2.19, Fabricate and integrate IPTD modifications at the HCF

Start 1-3-96, end 1-3-97

Expected effort:
RI - 9660 hrs
MFSC - TBD hrs

Task 2.2.20, Fabricate a thrust structure and modifications to the AETF to allow integration of the IPTD.

Start 1-3-97, end 1-3-98

Expected effort:
RI - 6300 hrs
MFSC - TBD hrs

Task 2.2.21, Fabricate SSTO simulations for the IPTD and integrate the thrust structure and IPTD into the AETF.

Start 1-3-98, end 6-30-98

Expected effort:
RI - 5620 hrs
MFSC - TBD hrs

6.2.3 TASK 2.3, PERFORM TEST OPERATIONS

This task is first initiated in phase 2 with the preliminary system checkout of the cold-flow propulsion module (Test Sequence 1), and continues through phase 4 with the integrated engine / system test operations. NASA is responsible for overall test operation activity with Rockwell providing support from monitoring the PCCS stations, to reviewing test data in a near real-time environment. This latter support is intended to assist NASA in test anomaly work-around and suggestions for real time test procedure revisions. Since this task is initiated in January 1996, this initial submittal of the program plan provides only a summary of the budget allocations and timing of the phase 2 through 4 task activity.

Task 2.3.1, Perform Test Sequence 1 at HCF

Start 1-3-96, end 5-1-96

Expected effort:
RI - 2880 hrs
MFSC - TBD hrs

Task 2.3.2, Perform Test Sequence 2 at HCF

Start 3-1-97, end 9-1-97

Expected effort:
RI - 4320 hrs
MFSC - TBD hrs

Task 2.3.3, Perform Test Sequence 3 at AETF

Start 6-1-98, end 12-1-98

Expected effort:
RI - 4320 hrs
MFSC - TBD hrs

6.3 TASK 3, DATA ANALYSIS AND UTILIZATION SUB TASK APPROACH

Task 3 analyzes test data, and applies the results to support requirements development, ongoing system trade studies, system modeling activities, and development of PCCS algorithms. Overall task objective is to reduce full scale propulsion system development and operability risk. Operability benefits of candidate improvements will be quantitatively assessed against a detailed Shuttle reference. All Shuttle propulsion-related checkout and verification requirements will be imposed on the IPTD model, and rationale will be developed to either maintain, change, or eliminate those requirements based on hardware or software improvements, process improvements, or demonstrated technological advancements.

Rockwell estimates include name labor and workhours where known for Phase 0 and Phase 1. For Phases 2, 3, and 4 an approximation of total Rockwell hours is included.

NASA participation is anticipated throughout Task 3 activities. However agreements have not yet been finalized and therefore names and workhours are TBD. Joint activities under Task 3 will be accomplished by a NASA/Rockwell Product Development Team (PDT). Rockwell will be responsible for PDT facilitation such as preparation of agendas and review material, as well as tracking and closing action items. NASA participants will contribute their technical expertise as PDT members and, in addition, will exercise oversight of PDT activities. Generally, Rockwell will perform all effort described in the Task 3 SOW. MSFC and KSC will provide concepts, consultation, and guidance through membership in the PDT.

6.3.1 TASK 3.1, UPDATE MODELS AND ALGORITHMS

Test results will be used to update the Shuttle-validated models shown in Table 7 for application to SSTO. Test results will also support development of the control laws and prototype simulator of the PCCS. All IPTD engineering and operations data will be collected during this task. Data includes test article and GSE fluid/thermal characteristics, test measurements, control system algorithms, and operations documentation. Man-hours, head count, and serial time to accomplish turnaround operations are also included. Pretest performance modeling will also be performed in this task to support development of test procedures. Once collected, the data will be processed to provide information necessary to update the models to enable reconstruction of test article performance.

TASK 3.1.1 <u>Participate In Preparation Of Plan Of Action</u>

Develop Task 3 implementation plans and prepare inputs to the Principal Investigator's project-level plan.

Start: Jul. 18, 1994
Complete: Aug. 15,1994
Assignment: J. Spears (Rockwell) - 40hrs

TASK 3.1.2 <u>Form Product Development Team (PDT)</u>

Establish a Task 3 PDT consisting of NASA and Rockwell members. PDT members will be responsible for development of specific sub task products to be defined during task implementation, and participation in PDT review and improvement of products developed by other members.

Start: Aug. 1, 1994
Complete: Aug. 15,1994
Assignment: J. Spears (Rockwell) - 4hrs

TASK 3.1.3 Develop Recommended IPTD Demonstration Requirements

Review previous studies to develop a listing of candidate operability improvement technologies and designs. In addition, as shown in Figure 11, brainstorm new ideas for improvements that may be demonstrable using the IPTD. Screen out those ideas which are either not technically feasible or are clearly not affordable. For those ideas which survive the feasibility and affordability screens develop an approximate relative ranking based on qualitative benefit/cost ratios. Note that since the ranking is approximate and relative, detailed quantitative analysis is not required.

Subject surviving candidates to a final screen to determine whether or not they have a sponsor willing to fund test and demonstration. For those candidates which are judged to be worthwhile but do not have a sponsor, attempt to "sell" the improvement to potential users.

After the final screen, rank surviving candidates according to relative benefit/cost ratios, and transmit to Task 1 to be considered for incorporation into the IPTD Program.

Start: Aug. 15, 1994
Complete: Sept. 15, 1994 - 32hrs
Assignment: J. Spears (Rockwell/Dny.) - 8hrs
M. Manley (Rockwell/Dny.) -4hrs
M. Merlin (Rockwell/Dny.) - 4hrs
J. Engle (Rockwell/KSC) - 4hrs
J. Huether (Rockwell/KSC) - 4hrs
TBD Propulsion (Rockwell/Dny.) - 4hrs
TBD Huntsville (Rockwell) - 4hrs
TBD NASA MSFC & KSC - 16hrs (4 x 4hrs/ea.)

TASK 3.1.4 Describe Baseline Set Of Models

As shown in Figure 12, first define specific needs for models. Then select a baseline set, and describe each model in the selected set. Include representative outputs of each model, and explain how each meets one or more defined needs.

Start: Aug. 15, 1994
Complete: Oct. 15, 1994 - 100hrs
Assignment: J. Spears (Rockwell/Dny.) - 27hrs
M. Manley (Rockwell/Dny.) -18hrs
M. Merlin (Rockwell/Dny.) - 27hrs
J. Engle (Rockwell/KSC) - 7hrs
J. Huether (Rockwell/KSC) - 7hrs
TBD Propulsion (Rockwell/Dny.) - 7hrs
TBD Huntsville (Rockwell) - 7hrs
TBD NASA MSFC & KSC - 28hrs (4 x 7hrs/ea.)

TASK 3.1.5 Adapt Models To IPTD Configuration

Most of the models needed for the IPTD Program already exist in some form as shown in Table 7. However, they must all be adapted to the IPTD, and many must be augmented or revised. This is an extremely critical, high-leverage sub task, which will set the stage for beneficial use of models throughout the rest of the program. Because of the significance of this sub task, its two primary sub tasks will be discussed individually.

TASK 3.1.5.1 Adapt Operations Models To IPTD Configuration

Operations models must quantitatively relate orbiter launch-site operations and IPTD test-site operations. "Operating" the IPTD in a Shuttle launch-site environment can then enable isolation of the affects of operability improvements from other influences. This approach eliminates misleading indications of apparent operability improvements which, in reality, are only results of differences between test stand and launch site requirements, policies, and procedures. Figure 13 shows the approach to combining Shuttle-style operations and Airline-style operations to produce a highly efficient--and safe--SSTO operations concept as described in the following sub tasks.

TASK 3.1.5.1.1 Establish Shuttle Processing Reference

As shown in Figure 14 obtain data describing KSC's end-to-end generic processing reference including end-to-end timelines, workforce requirements, and task linkages. Level of definition should be to the:

- Element level for the overall system.
- Sub system level within the Orbiter.
- Component or procedure level within the MPS.

Program all operations in MS Project and review with the PDT. The product then provides a reality-based starting point for development of the SSTO processing reference.

Start: Jul. 28, 1994
Complete: May 15, 1995 - 332hrs
Assignment: J. Spears (Rockwell/Dny.) - 90hrs
M. Manley (Rockwell/Dny.) -70hrs
M. Merlin (Rockwell/Dny.) - 70hrs
J. Engle (Rockwell/KSC) - 41hrs
J. Huether (Rockwell/KSC) - 41hrs
TBD Propulsion (Rockwell/Dny.) - 10hrs
TBD Huntsville (Rockwell) - 10hrs
TBD NASA MSFC & KSC - 40hrs (4 x 10hrs/ea.)

TASK 3.1.5.1.2 Develop Shuttle-Style SSTO Processing Reference

Starting with the Shuttle processing reference from 3.1.5.1.1, delete or add impacts due only to configuration differences between SSTO and Shuttle. As shown in Figure 15 the product of this step establishes a reference SSTO with all the same subsystem technologies, processes, and procedures as the Shuttle Orbiter. This sets the stage for estimating how much further SSTO timelines and costs can be reduced by implementing improved technologies and designs compared to the Orbiter. These are the improvements which can be assessed and demonstrated on the IPTD.

Start: Oct. 15, 1994
Complete: June 20, 1995 - 164hrs
Assignment: J. Spears (Rockwell/Dny.) - 44hrs
M. Manley (Rockwell/Dny.) -32hrs
M. Merlin (Rockwell/Dny.) - 28hrs
J. Engle (Rockwell/KSC) - 20hrs
J. Huether (Rockwell/KSC) - 20hrs
TBD Propulsion (Rockwell/Dny.) - 10hrs
TBD Huntsville (Rockwell) - 10hrs
TBD NASA MSFC & KSC - 40hrs (4 x 10hrs/ea.)

TASK 3.1.5.1.3 Develop Airline-Style SSTO Processing Reference

As shown in Figure 16, start with a clean sheet SSTO operations flow based on the PDT's qualitative judgment of how efficiently the SSTO can be operated. Using MA*trix*, incorporate airline operability parameters into the clean-sheet flow and program the flow in SIM*trix* to simulate end-to-end turnaround and MPS detailed processing. This simulation then represents SSTO operated as an airliner.

Start: Dec. 15, 1994
Complete: July 20, 1995 - 180hrs
Assignment: J. Spears (Rockwell/Dny.) - 20hrs
M. Manley (Rockwell/Dny.) -20hrs
T. Weber (Rockwell/Dny.) -90hrs
M. Merlin (Rockwell/Dny.) - 10hrs
J. Engle (Rockwell/KSC) - 10hrs
J. Huether (Rockwell/KSC) - 10hrs
TBD Propulsion (Rockwell/Dny.) - 10hrs
TBD Huntsville (Rockwell) - 10hrs
TBD NASA MSFC & KSC - 40hrs (4 x 10hrs/ea.)

TASK 3.1.5.1.4 Develop Proposed SSTO Operations Reference

Develop the SSTO operations reference by evolving the Shuttle-style reference to approach airline-style as closely as possible without compromising safety. Reductions of Shuttle-style timelines/workhours are made only when justified by IPTD test results or other substantiating data (e.g. DC-X) when unanimously agreed to by the PDT.

Start: April 17, 1995
Complete: Aug. 20, 1995 - 280hrs
Assignment: J. Spears (Rockwell/Dny.) - 70hrs
M. Manley (Rockwell/Dny.) -70hrs
T. Weber (Rockwell/Dny.) -70hrs
M. Merlin (Rockwell/Dny.) - 10hrs
J. Engle (Rockwell/KSC) - 20hrs
J. Huether (Rockwell/KSC) - 20hrs
TBD Propulsion (Rockwell/Dny.) - 10hrs
TBD Huntsville (Rockwell) - 10hrs
TBD NASA MSFC & KSC - 40hrs (4 x 10hrs/ea.)

TASK 3.1.5.2 Adapt Fluid/Thermal Models To IPTD Configuration

Implement adaptation techniques to enable application of Shuttle models to the IPTD.
Start: April 1, 1995
Complete: Aug. 31, 1995 - 300hrs
Assignment: J. Spears (Rockwell/Dny.) - 10hrs
M. Manley (Rockwell/Dny.) -10hrs
T. Weber (Rockwell/Dny.) -10hrs
M. Merlin (Rockwell/Dny.) - 100hrs
J. Engle (Rockwell/KSC) - 10hrs
J. Huether (Rockwell/KSC) - 10hrs
TBD Propulsion (Rockwell/Dny.) - 140hrs
TBD Huntsville (Rockwell) - 10hrs
TBD NASA MSFC & KSC - 40hrs (4 x 10hrs/ea.)

TASK 3.1.6 Predict SSTO Operations & Fluid/Thermal Parameters

Perform pretest modeling to help establish preliminary definition of the full scale SSTO in sub task 3.3.1. Using the models, estimate approximate values of key fluid/thermal and operations parameters applicable to the full scale SSTO.

Start: Sept. 1, 1995
Complete: Sept. 30, 1995 - 160hrs
Assignment: J. Spears (Rockwell/Dny.) - 37hrs
M. Manley (Rockwell/Dny.) - 37hrs
T. Weber (Rockwell/Dny.) - 37hrs
M. Merlin (Rockwell/Dny.) - 37hrs
J. Engle (Rockwell/KSC) - 4hrs
J. Huether (Rockwell/KSC) - 4hrs
TBD Huntsville (Rockwell) - 4hrs
TBD NASA MSFC & KSC - 16hrs (4 x 4hrs/ea.)

TASK 3.1.7 Prepare Recommended Demonstration & Measurement Requirements For Test Sequence 1

Perform pretest modeling to support development of test procedures and measurement requirements for Test Sequence 1. Predict values of key fluid/thermal and operations parameters for Test Sequence 1, and prepare recommended requirements for measurements needed to validate models.

Start: Oct. 2, 1995
Complete: Oct. 31, 1995 - 580hrs
Assignment: J. Spears (Rockwell/Dny.) - 120hrs
M. Manley (Rockwell/Dny.) - 80hrs
T. Weber (Rockwell/Dny.) - 120hrs
M. Merlin (Rockwell/Dny.) - 100hrs
J. Engle (Rockwell/KSC) - 40hrs
J. Huether (Rockwell/KSC) - 40hrs
TBD Propulsion (Rockwell/Dny.) - 40hrs
TBD Huntsville (Rockwell) - 40hrs
TBD NASA MSFC & KSC - 16hrs (4 x 4hrs/ea.)

TASK 3.1.8 Predict Test Sequence 1 Measurement Values

Use models to predict values of measurements to be made during Test Sequence 1. Use full model capability to place the features to be proven by TS 1 in context with total system operations. Since this will be the first use of the capability, accomplish debugging and refinement as modeling progresses

Start: Nov. 1, 1995
Complete: Dec. 31, 1995 - 1180hrs
Assignment: J. Spears (Rockwell/Dny.) - 140hrs
M. Manley (Rockwell/Dny.) -140hrs
T. Weber (Rockwell/Dny.) - 140hrs
M. Merlin (Rockwell/Dny.) - 200hrs
J. Engle (Rockwell/KSC) - 80hrs
J. Huether (Rockwell/KSC) - 80hrs
TBD Propulsion (Rockwell/Dny.) - 200hrs
TBD Huntsville (Rockwell) -200hrs
TBD NASA MSFC & KSC - 40hrs (4 x 10hrs/ea.)

TASK 3.1.9 Review Test Sequence 1 Data

Collect and review TS 1 data as it is developed. Compare predicted and measured values. Develop rationale to explain differences and develop plan for correcting.

Start: Apr. 1, 1996
Complete: Apr. 30, 1996
Assignment: Rockwell - 1000hrs
NASA - TBD

TASK 3.1.10 Update Models Based On Test Sequence 1 Data

Process test data to provide information necessary to update models and reconstruct test article performance. Validate models and prepare them for subsequent tests. Note, subsequent test sequences will be much more complex than TS 1, and will therefor require significantly expanded modeling capabilities.

Start: Jan. 15, 1996
Complete: Jun. 15, 1996
Assignment: Rockwell - 3000hrs
NASA - TBD

TASK 3.1.11 Prepare Recommended Demo & Measurement Requirements For TS 2

Perform pretest modeling to support development of test procedures and measurement requirements for Test Sequence 2. Predict values of key fluid/thermal and operations parameters for Test Sequence 1, and prepare recommended requirements for measurements needed to validate models.

Start: Oct. 2, 1996
Complete: Dec. 1, 1996
Assignment: Rockwell - 500hrs
NASA - TBD

TASK 3.1.12 Predict Test Sequence 2 Measurement Values

Use models to predict values of measurements to be made during Test Sequence 2. Use full model capability to place the features to be proven by TS 2 in context with total system operations. Accomplish debugging and refinement as modeling progresses.

Start: Sept. 1, 1996
Complete: Feb. 1, 1997
Assignment: Rockwell - 4400hrs
NASA -TBD

TASK 3.1.13 Review Test Sequence 2 Data

Collect and review TS 2 data. Compare predicted and measured values. Develop rationale to explain differences and develop plan for reconciling.

Start: Apr. 1, 1997
Complete: Sept. 15, 1997
Assignment: Rockwell - 2000hrs
NASA - TBD

TASK 3.1.14 Update Models Based On Test Sequence 2 Data

Process test data to provide information necessary to update models and reconstruct test article performance. Validate models and prepare them for subsequent tests. Note that subsequent test sequences will be much more complex than TS 1, and will therefor require significantly expanded modeling capabilities.

Start: Mar 3, 1997
Complete: Nov. 3, 1997
Assignment: Rockwell - 3000hrs
NASA - TBD

TASK 3.1.15 Prepare Recommended Demo & Measurement Requirements For TS 3

Perform pretest modeling to support development of test procedures and measurement requirements for Test Sequence 2. Predict values of key fluid/thermal and operations parameters for Test Sequence 1, and prepare recommended requirements for measurements needed to validate models.

Start: Mar. 2, 1998
Complete: April 30, 1998
Assignment: Rockwell - 800hrs
NASA - TBD

TASK 3.1.16 Predict Test Sequence 3 Measurement Values

Use models to predict values of measurements to be made during Test Sequence 2. Use full model capability to place the features to be proven by TS 2 in context with total system operations. Accomplish debugging and refinement as modeling progresses.

Start: Jan. 1, 1998
Complete: Jun. 30, 1998
Assignment: Rockwell - 1600hrs
NASA TBD

TASK 3.1.17 Review Test Sequence 3 Data

Collect and review TS 1 data. Compare predicted and measured values. Develop rationale to explain differences and develop plan for reconciling.

Start: Jun. 51, 1998
Complete: Dec. 15, 1998
Assignment: Rockwell - 2000hrs
NASA - TBD

TASK 3.1.18 Update Models Based On Test Sequence 3 Data

Process test data to provide information necessary to update models and reconstruct test article performance. Validate models and prepare them for subsequent tests. Note that subsequent test sequences will be much more complex than TS 1, and will therefor require significantly expanded modeling capabilities.

Start: Jul. 1, 1998
Complete: Dec. 20, 1998 - 2000hrs
Assignment: Rockwell - 2000hrs
NASA - TBD

6.3.2 TASK 3.2, EXTRAPOLATE DATA TO FULL SCALE SYSTEMS

Identify differences between the IPTD and a full scale operational SSTO. Use the models developed in Task 3.1 to predict fluid/thermal, as well as operational, performance of the SSTO propulsion system. Develop techniques to account for identified IPTD and full scale differences that impact modeling, e.g., size, layout, environment, additional/interactive subsystems, and restricted access. Update the models from Task 3.1 to account for these differences.

TASK 3.2.1 Extrapolate Test Sequence 1 Data

Perform the extrapolation described in 3.2 using TS-1 data.

Start: Jun. 1, 1996
Complete: Aug. 30, 1996
Assignment: Rockwell - 1000hrs
NASA - TBD

TASK 3.2.2 Extrapolate Test Sequence 2 Data

Perform the extrapolation described in 3.2 using TS-2 data.

Start: Nov. 3, 1997
Complete: Dec. 15, 1997
Assignment: Rockwell - 1000hrs
NASA - TBD

TASK 3.2.3 Extrapolate Test Sequence 3 Data

Perform the extrapolation described in 3.2 using TS-3 data.
Start: Sept. 1, 1998
Complete: Dec. 20, 1998
Assignment: Rockwell - 1000hrs
NASA - TBD

6.3.3 TASK 3.3, RECOMMEND FULL SCALE SSTO MPS REQUIREMENTS & DESIGN FEATURES

Use the models updated in sub task 3.1 and extrapolated in sub task 3.2 to derive requirements for full scale SSTO system configurations obtained from parallel system studies. Figure 16 shows the relationship between IPTD MPS technology testing and SSTO requirements. IPTD test results and the model extrapolations from Task 3.2 will be used to define engine, MPS, tank design, and operational requirements for SSTO. This sub task also covers the continuous interaction that will be maintained between the IPTD program and the engine and tank manufacturers involved in other MSFC NRAs.

TASK 3.3.1 Establish Preliminary Definition Of Full Scale SSTO Requirements And Design Features

Use available information from MSFC system studies to establish preliminary definition of full scale SSTO requirements and design features. The product of this sub task constitutes the baseline against which candidate requirements and design features will be assessed. This sub task is primarily a coordination effort to assure that Task 3 assessments use a system definition consistent with mainstream MSFC studies.

Start: Oct. 3, 1994
Complete: Feb. 15, 1995 - 24hrs
Assignment: J. Spears (Rockwell/Dny.) - 8hrs
M. Manley (Rockwell/Dny.) -4hrs
M. Merlin (Rockwell/Dny.) - 4hrs
J. Engle (Rockwell/KSC) - 2hrs
J. Huether (Rockwell/KSC) - 2hrs
TBD Huntsville (Rockwell) -2hrs
TBD NASA MSFC & KSC - 120hrsR. Rhodes (NASA/KSC) - 20hrs

TASK 3.3.2 Update SSTO Definition Based On Test Sequence (TS) -1 Extrapolation

Use TS-1 extrapolations from Task 3.2.1 to establish recommended SSTO requirements and design features.

Start: Sept. 2, 1996
Complete: Nov. 15, 1996
Assignment: Rockwell - 705 hrs
NASA - TBD

TASK 3.3.3 Update SSTO Definition Based On TS-2 Extrapolation

Use TS-2 extrapolations from SUB TASK 3.2.2 to update and refine recommended SSTO requirements and design features.

Start: Nov. 1, 1997
Complete: Dec. 31, 1997
Assignment: Rockwell- 2890hrs
NASA - TBD

TASK 3.3.4 Update SSTO Definition Based On TS-3 Extrapolation

Use TS-3 extrapolations from SUB TASK 3.2.3 to update and refine recommended SSTO requirements and design features.

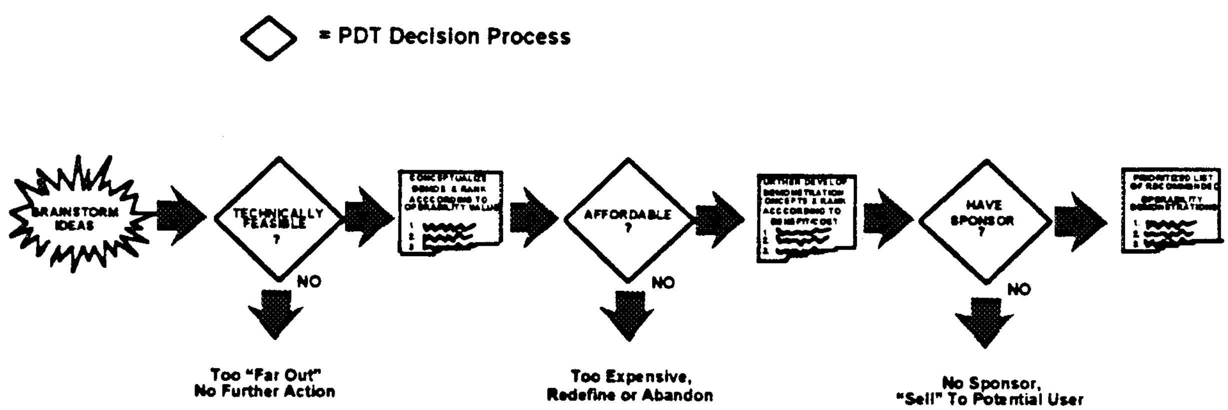
Start: Nov.2, 1998
Complete: Dec. 31, 1998
Assignment: Rockwell - 4320 hrs
NASA - TBD

Table 7 Task 3 Model Applications

Tool/Platform	Description	Application to Intended Job	Validation Phase
SIMtrix/PC	Simulates MPS ground processing flow to the procedure level	Used to evaluate alternative methods/technologies for MPS operations processing. Outputs include downtime, manpower, man-hours per MPS processing procedure	0 - 4
MAtrix/PC	Estimates values for key R&M parameters at the vehicle, system, and component levels	Used to apply commercial and DOD aircraft maintainability database to analysis of launch vehicles	0- 4
MPS Pressurization System Performance Prediction/ Reconstruction/IBM mainframe	Predicts ET ullage pressure profile for missions in conjunction with multiple failures of flow control valves	Used to predict tank ullage pressure profile and calculate tank ullage temperature, pressure, and total pressurant mass	1, 2 (prepress) 3, 4
MPS Feed System Performance Prediction Model/IBM mainframe	Calculates propellant temperatures, vapor pressure, line losses, and net positive suction pressure required and available at each SSME using initial conditions for LO_2 and LH_2	Used to investigate fluid conditions and cavitation in line sections and/or valves	3, 4

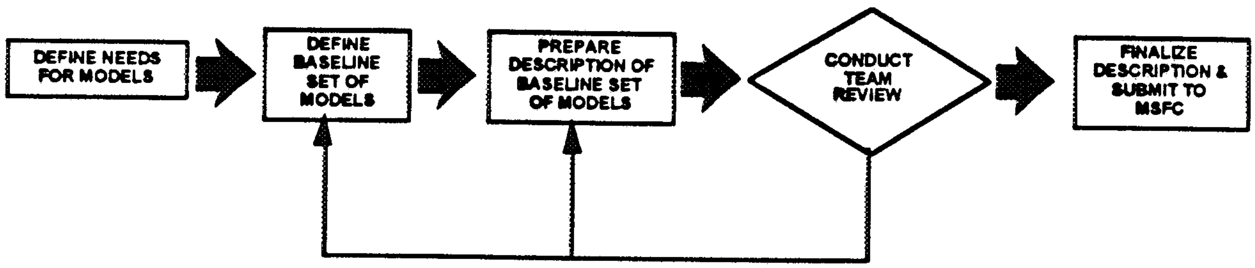
MPS Propellant Loading Model/HP9000	Simulates Shuttle propellant loading from start of chill-down through topping to 100%	Used to define propellant loading time lines, liquid and boil-off flow rates, pressures, and temperatures throughout the loading system	1 - 4
Passive, No-Bleed, Prestart Thermal Conditioning Model/ HP9000	Computes temperature gradient in engine feed line based on feed line geometry and thermal characteristics	Used for gaining physical insight into passive recirculation flow field	1 - 4
Main Propulsion System Integration Tool/PC	Optimizes feed system diameters to minimize combined weight of feed system and residuals	Used for feed system sizing and assessing weight impacts of changes in structural/engine pressure requirements	0 - 4

APT-T-4006



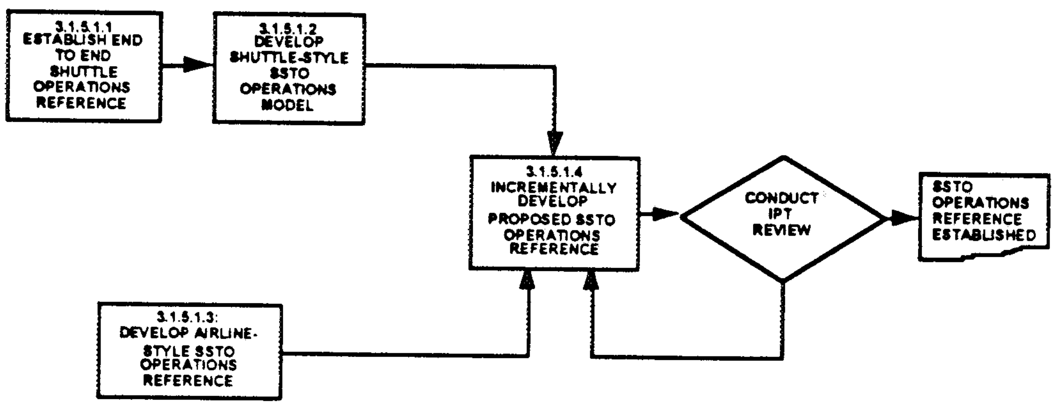
Notes:
- **Initial recommendations formulated as objectives.**
- **Detailed requirements (e.g., for measurements) to be developed on a schedule compatible with Tasks 1 & 2.**

Figure 11, Develop Recommended IPTD Demonstration Requirements



Note: Same Functional Flow Applies For Operations Models and Fluid/Thermal Models.

Figure 12, Describe Baseline Set Of Models



Notes:

- **Airline-Style Operations Establishes Floor.**
- **Shuttle-Style Operations Establishes Ceiling.**
- **SSTO Operations Reference To Be Incrementally Established As Follows:**
  - **Start With Shuttle-Style SSTO Operations Model.**
  - **Apply New Technology & Design Improvements To Transform Shuttle-Style To Airline-Style Operations, To The Extent Possible Without Compromising Safety or Required System Capability.**
  - **Quantitatively Establish Value Of Each Incremental Transformation Step By Actual Test Data.**

Figure 13, Adapt Operations Models To IPTD Configuration

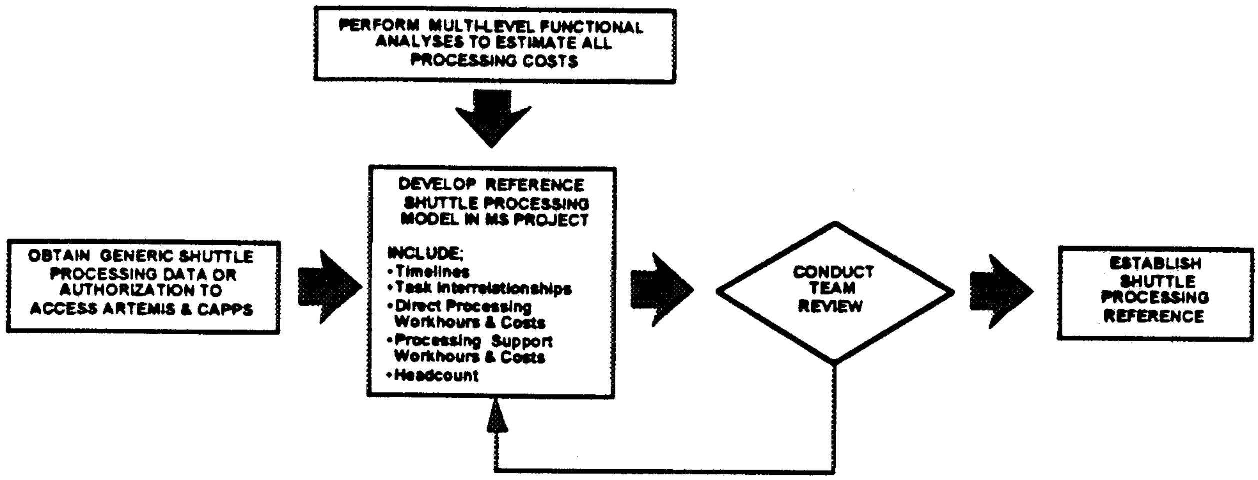


Figure 14, Establish End-To-End Shuttle Operations Reference

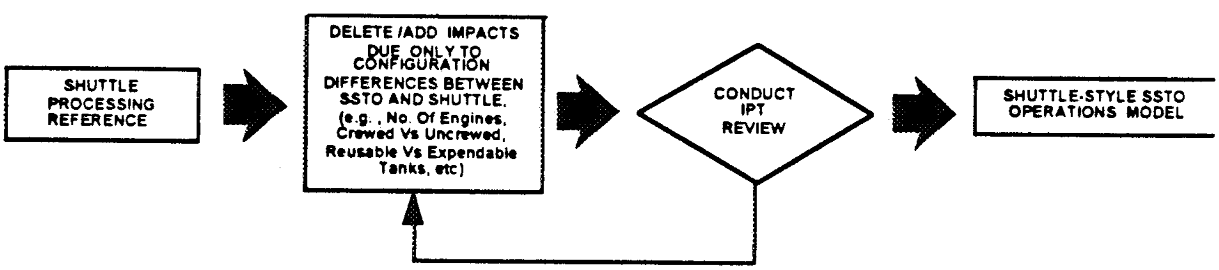


Figure 15, Develop Shuttle-Style SSTO Operations Reference

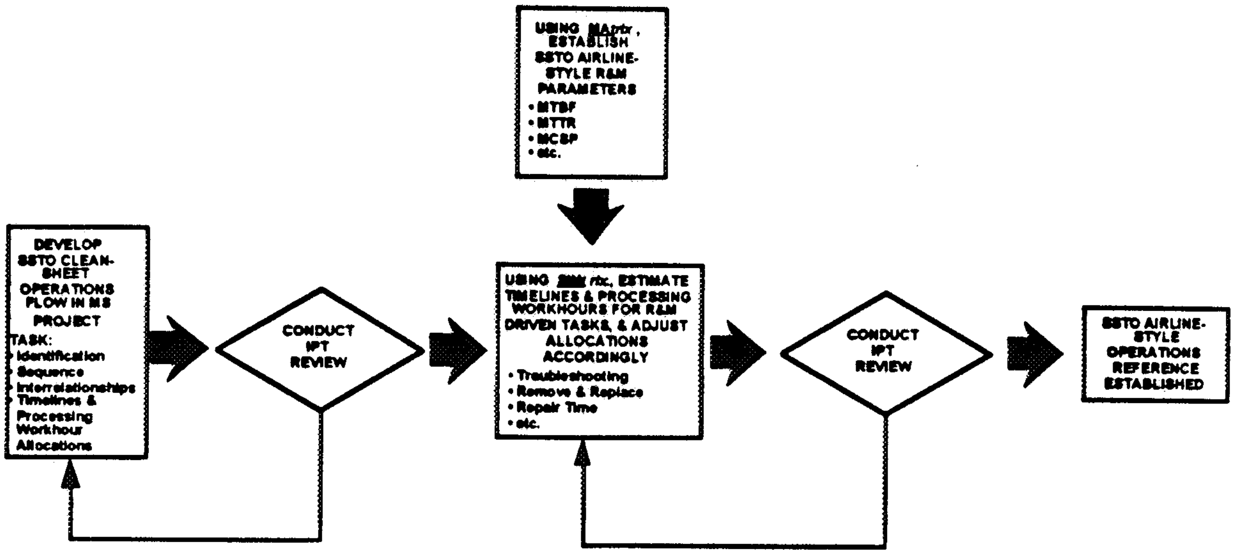


Figure 16, Develop Airline-Style SSTO Operations Reference

7. SUB TASK SCHEDULE AND MILESTONES

Based on the sub task description input provided in Section 6., an integrated program schedule has been developed, and is presented in Attachment 1 for each task. Interim milestones are specified for each sub task, and the billing milestones are grouped within the project management task (Task 4). The program schedule will be updated periodically, and specified with a revision number. Each task leader will monitor task progress and update the percent complete estimate at the end of each week.

8. FACILITY AND CAPITAL EQUIPMENT REQUIREMENTS

There is no anticipated need for co-location within a NASA or Rockwell facility for personnel from each other's organization through FY 1995. Except for the use of existing engineering office areas within both NASA and Rockwell, there are no facility or capital expenditure requirements anticipated for tasks 1 and 3. Task 2 requires both test facility and equipment support from NASA and Rockwell, Table 8 for sub task 2.1.1. In addition, both Rockwell capital expenditure, and NASA laboratory facilities, shown in Table 9 are required to support sub task 2.1.2.

9. TRAVEL AND MATERIAL PURCHASE REQUIREMENTS

Travel requirements corresponding to each sub task is presented in Table 10 or FY 94-95. There are no material purchase requirements for Tasks 1 and 3. A description of the material requirements and associated timing is shown in Table 11.

Table 8 Sub task 2.1.1 Facility & Capital Equipment Requirements

Location	Building	Need Date	Use and Capability
Downey	001	7/1/94	Program office-furniture and fixtures; PC and reprographics distribution; local area network (LAN) and telecommunications saturation
	286	4/1/95	Cryogenic simulation and test laboratory-control room; 6 test cells; concrete enclosed; H_2 detection system ventilation; CO_2 purge and sprinklers; 14,000-gal. LN_2 Dewar, 2,500-gal. LH_2 Dewar
	288	4/1/95	Dynamics high-bay laboratory-Equivalent in height to a 10-story building; access via a 68-ft-high horizontal rolling door; two bridge cranes rated at 35 and 15 tons each with a hook height of 85 ft
		4/1/95	Machining and fabrication center-Fully equipped machine, sheet metal, and heavy fixture fabrication shop; includes lathes, mills, drill presses, shapers, welding machines, and fabricators; air-conditioned; enclosed; adjacent to 3,000-ft^2 fabrication canopy with two 3,000-lb bridge cranes
		4/1/95	Clean room-Class 100,000 rating
MSFC	4674	11/1/95	West Test Area block house-Blast resistant block house; total of 27,000 ft^2; contains remote controls and instrumentation recording system for entire West Test Area (including test position 4670)
	4670	1/3/98	Propulsion stage test stand-406-ft high with 200 ton and 150-ton derricks; 7,000,000 gal. industrial water storage capacity; 750,000 gal. LH_2 storage; 7,080 ft^3 GN_2 system, 3,750 ft^3 GHe system, 12,500 ft3 GH_2 system; 70 ft^3 air supply at 3,5000 psig; 370 gpm hydraulic system at 3,000 psig
	4626	9/1/95	LH_2 cold flow facility for bipropellant and tripropellant loading evaluation
	4671	11/1/95	Test facility support building-service structure for West Test Area. IPTD arrival
	4653	11/1/95	Components service and repair facility-total of 16,000 ft^2 for support of office, utilities, and storage of valve repair parts; 20-ft high-bay area; 3- and 5-ton bridge cranes with 15-ft hook height; includes component support shop and two test cells

Table 9 Sub task 2.1.2 Facility & Capital Equipment Requirements

Location	Building	Need Date	Use and Capability
Downey	004	12/1/94	Simulation and Controls Laboratory, PC distribution; local area network (LAN) and telecom, PCCS capital equipment*
	004	12/1/94	PCCS capital equipment* Sun LX workstaion (3) Sparc 10 server (1) Visual workstation (1 SGI) Portable workstation (1 RDI LX) Front End Processor (1) I/O boards & interfaces (8) R3000 single board computer (4) VME Chassis (3) Bit 3 (1) 1553 B (3) Telemetry (Rcv/Trns) (1) Systran (4)
MSFC	4674	11/1/95	West Test Area block house-Blast resistant block house; total of 27,000 ft^2; contains remote controls and instrumentation recording system for entire West Test Area (including test position 4670)
	4476	1/3/95	Marshall Avionics System Testbed and Flight Simulation Lab; EAI Simstar for high fidelity engine simulation; Sun and Silicon Graphics workstations for data display and software development
LeRC		TBD	TBD
ARC		TBD	TBD

Table 10 FY 94-95 Travel Requirements

SUB TASK	DATE	FROM-TO	NO. OF PERSONNEL	PURPOSE	ESTIMATED COST
1.1	9/14-15/94	Downey-Huntsville	2	Consolidate / coordinate SSTO program " needs"/ Establish technology readiness & assignments for sub task 2.2	$2,300
1.2	10/26-27/94	Downey-Huntsville	2	Coordinate specific test objectives, prioritize objectives, make inputs to final report, and select test objectives for IPTD program	$2,300
2.1.1	4/14-16/95	Downey-Huntsville	2	Support interim design review	$2,500
2.2.17	12/4-9/95	Downey-Huntsville	1	Coordinate the integration of propulsion module next to HCF	$1,400
2.2.17	12/4-16/95	Downey-Huntsville	1	Perform close-out cryo insulation of propulsion module fill/drain and feed system	$2,900
2.1.2	10/15/94	Downey-Huntsville	2	Identify usable assets and review/update preliminary PCCS architecture	$2,400
2.1.2	6/5/95	Downey-Cleveland (LeRC)	2	Review and achieve PCCS team consensus on PCCS concept definition and interface requirements	$2,400
2.1.2	10/25/95	Downey-Huntsville	1	Support PCCS integration at MSFC HCF, test, and checkout	$10,000
2.1.2	12/15/95	Downey-Huntsville	2	Support PCCS Sequence 1 Test readiness review	$2,400
3.1	10/11-13/94	Downey-Orlando (KSC)	3	Achieve operations PDT consensus on establishment of baseline set of models	$3,700
4.	9/12-14/94	Downey-Huntsville	2	Coordinate, and finalize program plan	$2,300
4.	TBD in FY95	Downey-Huntsville	1	Support interchange meetings (3) with NASA management	$3500

Note:
Assume estimated cost ~ # of personnel *($1000/person + $75/person day * # of days) for typical (non extended leave) travel.

Table 11, Material Purchase Description

TASK NUMBER	ORDER DATE	MATERIAL DESCRIPTION	ON-DOCK ARRIVAL DATE	EST. COST
2.2.1	9/28/94	NEW COMPONENTS AND REPAIR PARTS FOR EXISTING COMPONENTS	1/15/85	$20K
2.1.1.6	1/31/95	NEW SENSORS AND SIGNAL CONDITIONING FOR PROPULSION MODULE	7/1/95	$25K
2.1.1.7	1/3/95	STRUCTURAL BEAMS TO CONNECT IPTD TO HCF PIERS	2/20/95	$5K
2.1.1.9	1/31/95	STRUCTURAL STEEL FOR LIFTING SLINGS AND IPTD PIVOT JOINTS	3/20/95	$5K
2.1.1.10	2/28/95	SENSORS TO DETECT GH2 LEAKAGE	7/1/95	$10K
2.1.1.13	2/15/95	STRUCTURAL BEAMS FOR PROPULSION MODULE STRUCTURE	4/1/95	$10K
2.1.1.14	4/1/95	PIPE AND PIPE FITTINGS, TUBING, INSULATION MATERIAL, AND FITTINGS	5/15/95	$12K
2.1.1.16	5/31/95	ADDITIONAL SENSORS AND SIGNAL CONDITIONING UNITS	8/1/95	$25K
2.1.1.17	5/31/95	PIPE AND SPRAY HEADS FOR FIRE-EX SYSTEM	7/15/95	$1K
2.1.1.18	JAN. - JUN., 96	PROPELLANT TANKS, AND PLUMBING, SUBSYSTEM MODULE STEEL, AND INSTRUMENTATION	TBD	$442K
2.1.1.19	JAN. - JUL., 97	THRUST STRUCTURE STEEL, MODS. TO IPTD, SYSTEM UPGRADES, AND INSTRUMENTATION	TBD	$155K

ATTACHMENT 1

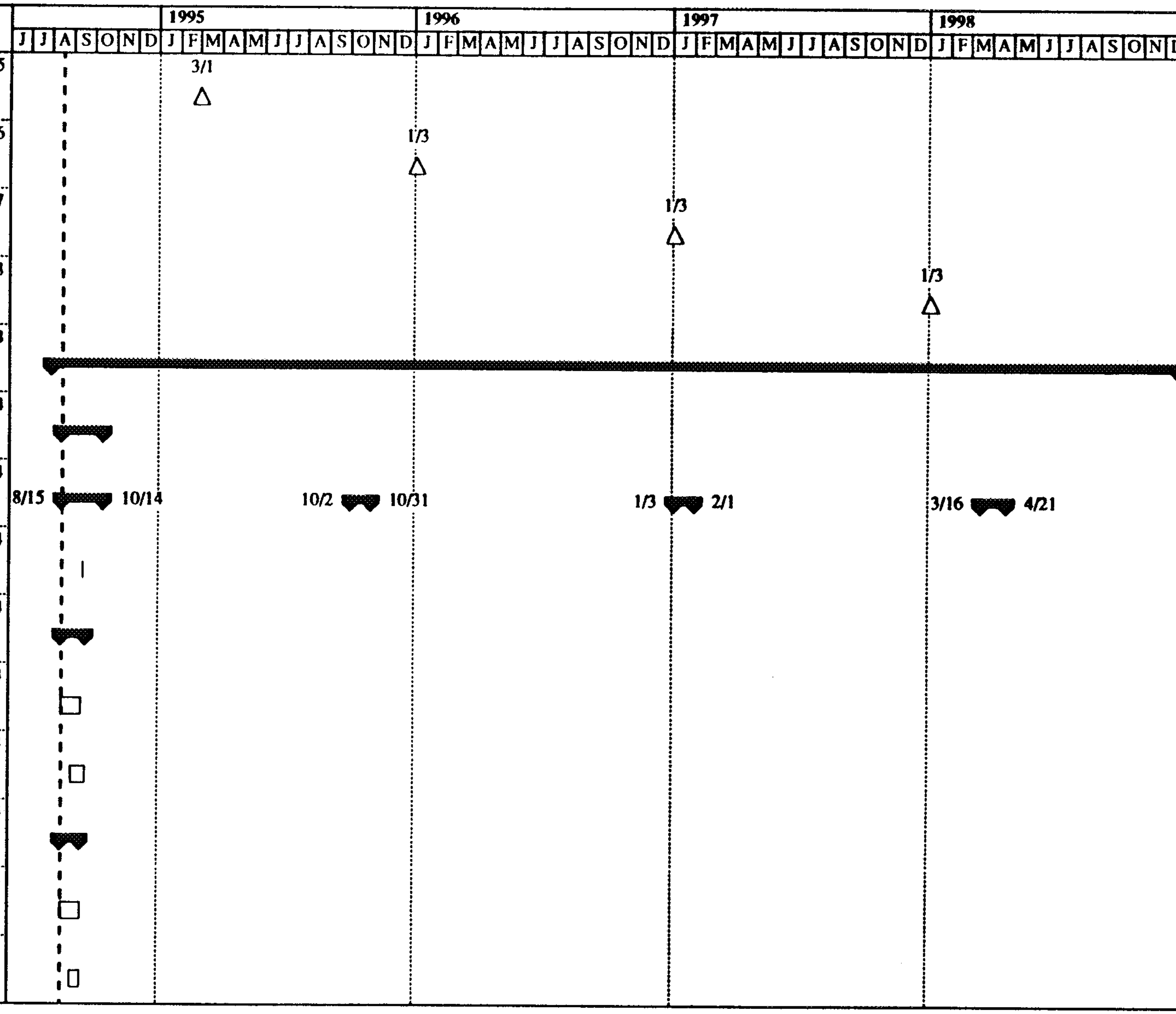
SUB TASK SCHEDULES

NRA 8-11 TA1B

Integrated Propulsion Technology Demonstrator

Task 1- Test Requirements And Plans

ID	Description	Start	Finish
11	Initiate Phase 1 (Boat Tail Design & Fab.)	3/1/95	3/1/95
19	Initiate Phase 2 (Boat Tail Integ. Tests & Tank Fab.)	1/3/96	1/3/96
31	Initiate Phase 3 (Tri-Propellent Integ. Cold Flow Test)	1/3/97	1/3/97
43	Initiate Phase 4 (Integrated Engine Sys. Test)	1/3/98	1/3/98
55	**Task 1 - Test Requirements & Plans**	**8/1/94**	**12/21/98**
56	**1.1 Identify System Improvement Needs**	**8/15/94**	**10/14/94**
57	Task 1.1 Summary	8/15/94	10/14/94
58	Team Meeting	9/14/94	9/15/94
59	**1.1.1 SSTO**	**8/15/94**	**9/19/94**
60	Document Review	8/15/94	9/12/94
61	Verbal Reviews	8/29/94	9/19/94
62	**1.1.2 ELV**	**8/15/94**	**9/12/94**
63	Document Review	8/15/94	9/12/94
64	Verbal Reviews	8/29/94	9/12/94

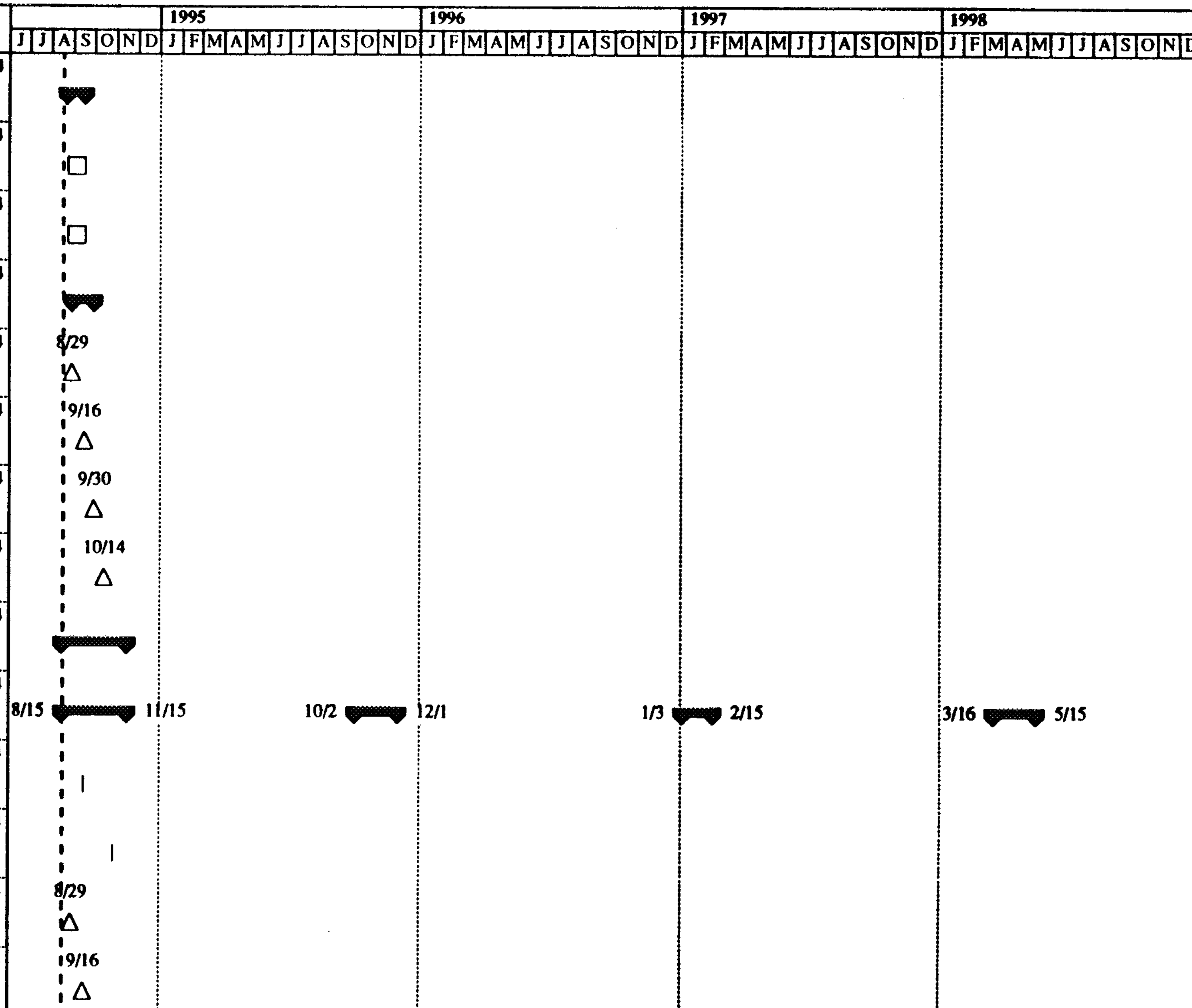


NRA 8-11 TA1B

Integrated Propulsion Technology Demonstrator

Task 1- Test Requirements And Plans

ID	Description	Start	Finish
65	1.1.3 Technology Critique	8/22/94	9/16/94
66	NASA	8/22/94	9/16/94
67	Industry	8/22/94	9/16/94
68	1.1.4 Consolidate Results & Report Preparation	8/29/94	9/30/94
69	Task 1.2 Data Dump I	8/29/94	8/29/94
70	Task 1.2 Data Dump II	9/16/94	9/16/94
71	Task 1.2 Data Dump III	9/30/94	9/30/94
72	Conclude	10/14/94	10/14/94
73	1.2 Identify Test Objectives	8/15/94	11/15/94
74	Task 1.2 Summary	8/15/94	11/15/94
75	Team Meeting	9/14/94	9/15/94
76	Team Meeting	10/26/94	10/27/94
77	Task 1.1 Data Input I	8/29/94	8/29/94
78	Task 1.1 Data Input II	9/16/94	9/16/94

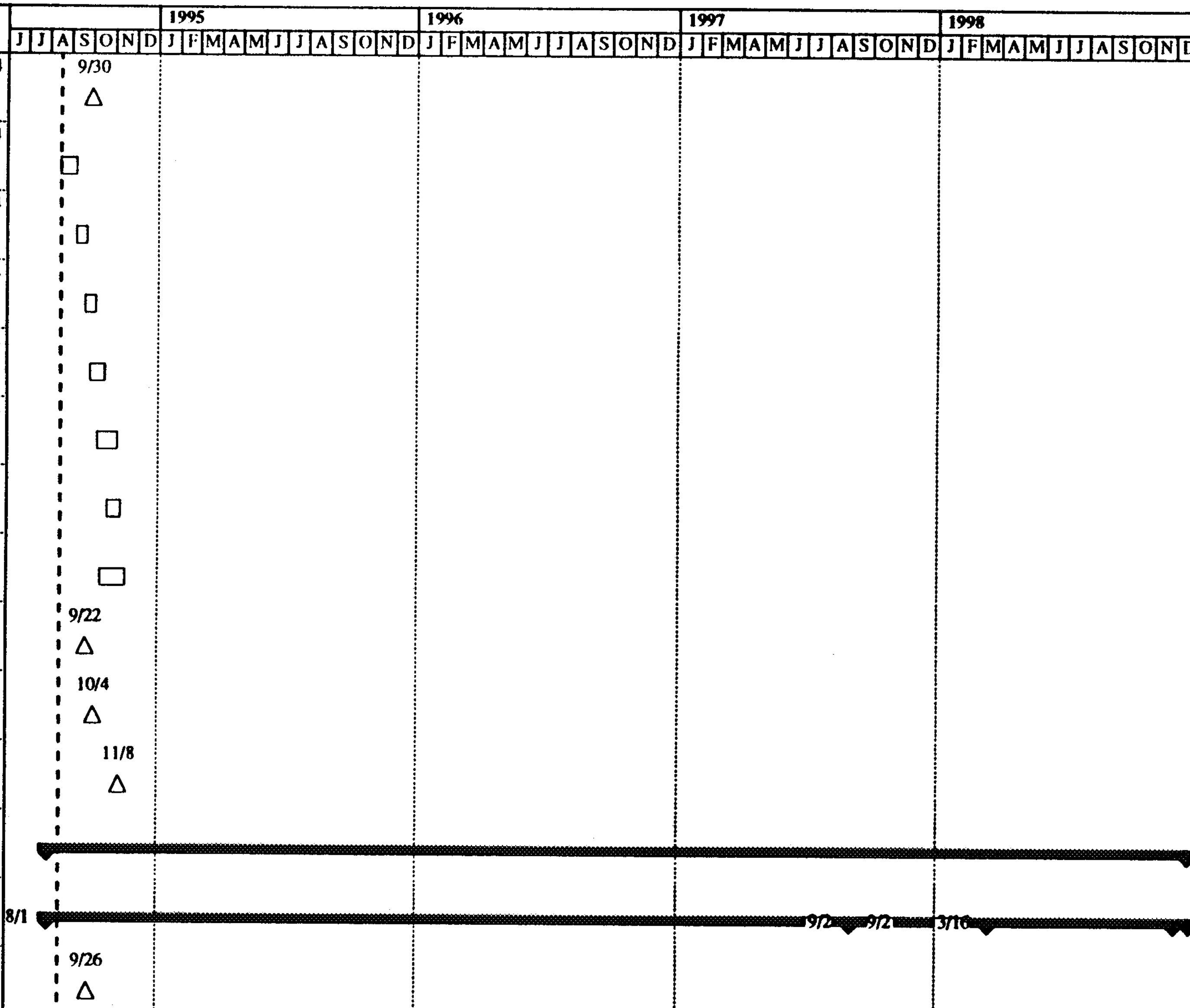


NRA 8-11 TA1B

Integrated Propulsion Technology Demonstrator

Task 1- Test Requirements And Plans

ID	Description	Start	Finish
79	Task 1.1 Data Input III	9/30/94	9/30/94
80	1.2.1 Develop Assessment Parameters	8/15/94	9/7/94
81	1.2.2 Technology Readiness State for Program Needs	9/7/94	9/22/94
82	1.2.3 Criticality of Technology Inadequacies	9/19/94	10/4/94
83	1.2.4 NRA 8-11 Capabilities/Technolo Inadequacies	9/26/94	10/17/94
84	1.2.5 Test Objective Developement/Assess	10/6/94	11/4/94
85	1.2.6 Test Objective/NRA 8-11 Program Integration	10/20/94	11/8/94
86	1.2.7 Report Prepartion	10/11/94	11/15/94
87	Task 1.3 Data Dumps	9/22/94	9/22/94
88	Task 1.3 Data Dumps	10/4/94	10/4/94
89	Task 1.3 Data Dumps	11/8/94	11/8/94
90	1.3 Prep. Design Reqts, Test Plans, & Proc.	8/1/94	12/21/98
91	Task 1.3 Summary	8/1/94	12/21/98
92	Task 1.2 Data Input	9/26/94	9/26/94

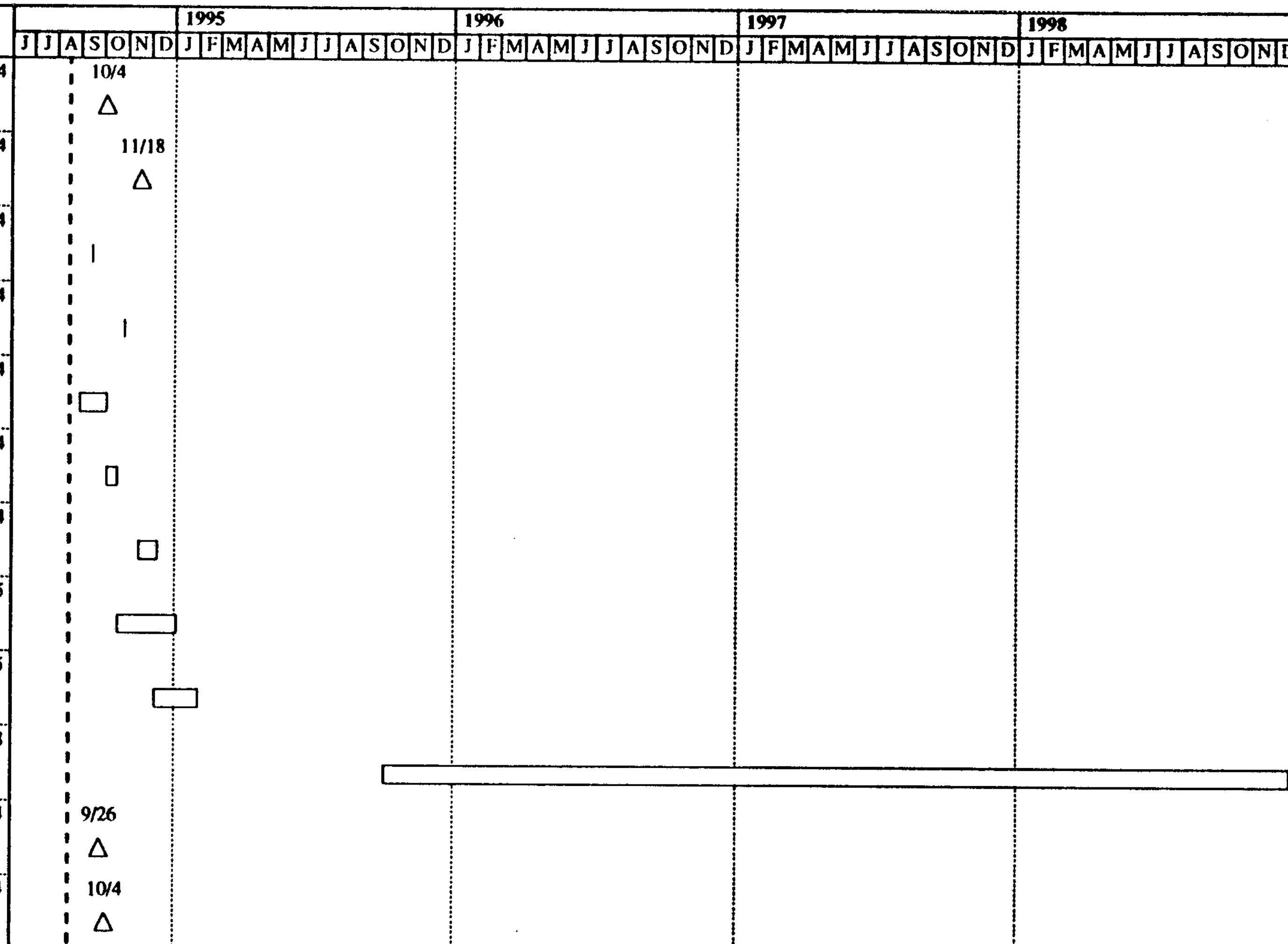


NRA 8-11 TA1B

Integrated Propulsion Technology Demonstrator

Task 1- Test Requirements And Plans

ID	Description	Start	Finish
93	Task 1.2 Data Input	10/4/94	10/4/94
94	Task 1.2 Data Input	11/18/94	11/18/94
95	Team Meeting	9/14/94	9/15/94
96	Team Meeting	10/26/94	10/27/94
97	1.3.1Top Level Prelim. Design Reqts	8/29/94	10/3/94
98	1.3.2 Test Plan Outline	10/3/94	10/17/94
99	1.3.3Test Program Structuring	11/14/94	12/9/94
100	1.3.4 Develop Supporting Data, Criteria, etc.	10/17/94	1/3/95
101	1.3.5 Prepare Test Plan	12/5/94	1/31/95
102	1.3.6 Specific Test Procedures	10/1/95	12/21/98
103	Prelim. Design Data Dump I	9/26/94	9/26/94
104	Prelim. Design Data Dump I	10/4/94	10/4/94

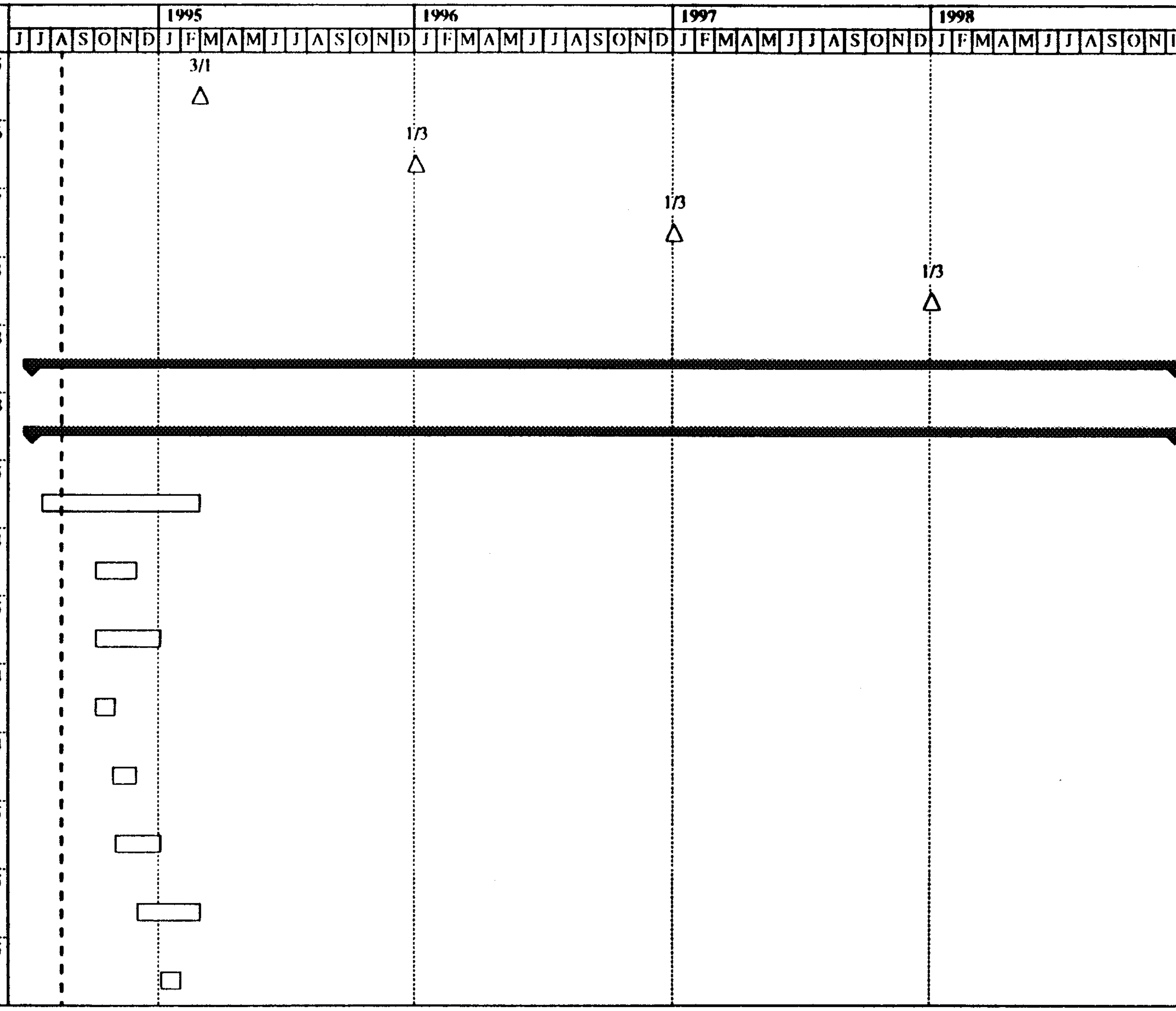


NRA 8-11 TA1B

Integrated Propulsion Technology Demonstrator

Task 2 - Assembly And Operation

ID	Description	Start	Finish
11	Initiate Phase 1 (Boat Tail Design & Fab.)	3/1/95	3/1/95
19	Initiate Phase 2 (Boat Tail Integ. Tests & Tank Fab.)	1/3/96	1/3/96
31	Initiate Phase 3 (Tri-Propellent Integ. Cold Flow Test)	1/3/97	1/3/97
43	Initiate Phase 4 (Integrated Engine Sys. Test)	1/3/98	1/3/98
105	**Task 2 - IPTD Assembly & Operation**	**7/6/94**	**12/15/98**
106	**Task 2.1 - Establish IPTD Design**	**7/6/94**	**12/15/98**
108	2.1.1.1 RI/MSFC Design Coordination	7/19/94	2/28/95
109	2.1.1.2 Prelim. IPTD Design	10/3/94	11/30/94
110	2.1.1.3 Design IPTD/HCF Pier Supports	10/3/94	1/3/95
111	2.1.1.4 Prelim. Propellant Tank Design	10/3/94	10/31/94
112	2.1.1.5 Prelim. Propulsion Mod. Design	10/28/94	11/30/94
113	2.1.1.6 Procure Propulsion Mod. Instrumentation	10/31/94	1/3/95
115	2.1.1.8 Design HCF Propulsion Mod. Integration Mods	12/1/94	2/28/95
116	2.1.1.9 Design IPTD Lifting & Rotation Fixtures	1/3/95	1/31/95

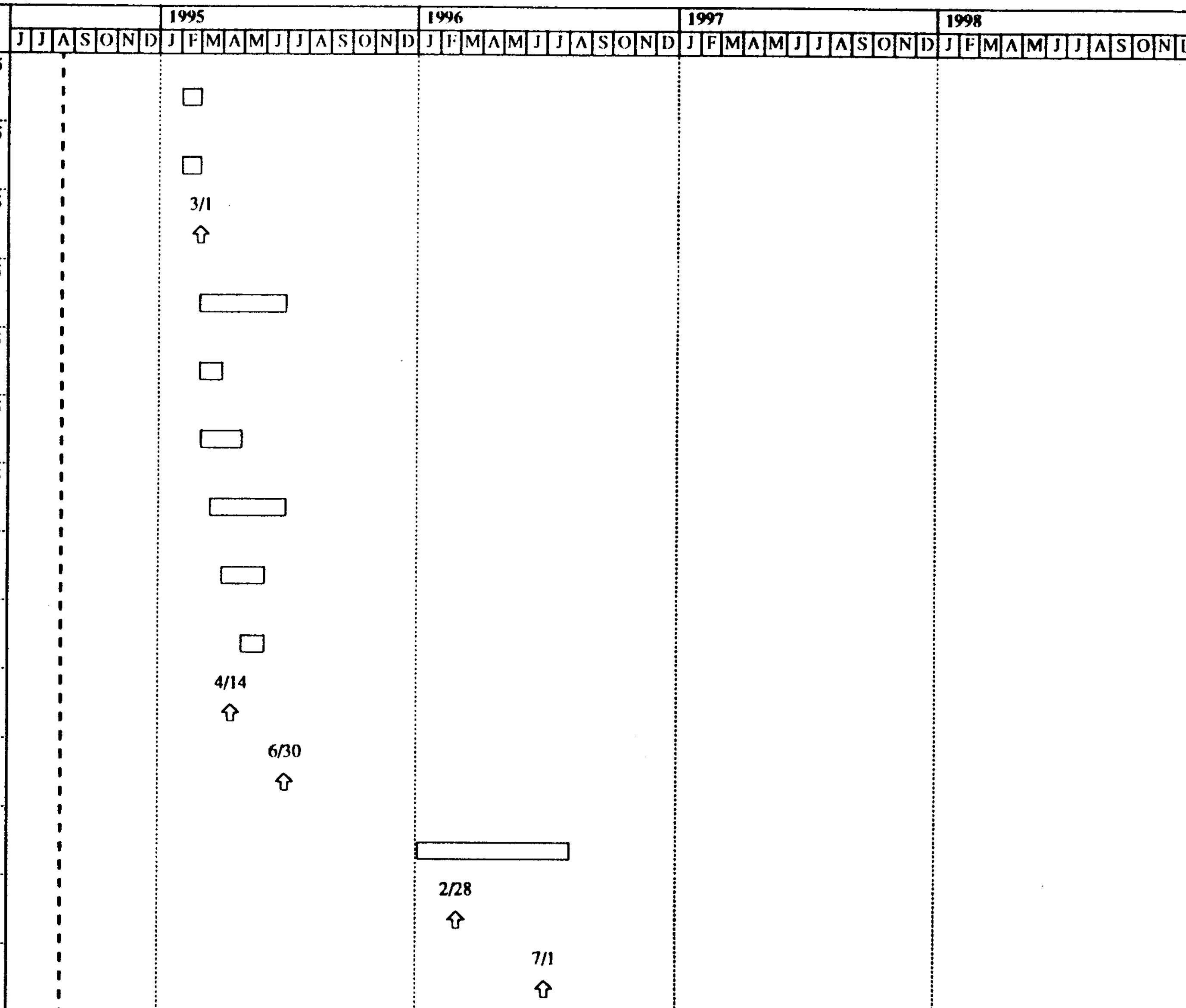


NRA 8-11 TA1B

Integrated Propulsion Technology Demonstrator

Task 2 - Assembly And Operation

ID	Description	Start	Finish
117	2.1.1.10 Design Prop Module Haz Gas Detection Systems	2/1/95	2/28/95
118	2.1.1.11 Propulsion Module Design Review	2/1/95	2/28/95
119	Submit HCF Pier Support Design Requirements	3/1/95	3/1/95
120	2.1.12 RI/MSFC Design Coordination	2/27/95	6/30/95
121	2.1.13 Complete Propulsion Module Design	2/27/95	3/31/95
122	2.1.14 Design Propulsion Module Plumbing & Brackets	3/1/95	4/28/95
123	2.1.15 Design Propulsion Module Instrumentation	3/14/95	6/30/95
124	2.1.16 Procure Propulsion Module Instrumentation	3/31/95	5/31/95
125	2.1.17 Design Propulsion Module Fire-Ex System	4/28/95	5/31/95
126	Iterim Design Review	4/14/95	4/14/95
127	Submit Propulsion Module Design	6/30/95	6/30/95
128	2.1.18 Design Mods To The IPTD To Incorporate	1/3/96	8/5/96
129	Interim Design Review	2/28/96	2/28/96
130	Submitt Propellant Module Design Data Book	7/1/96	7/1/96



NRA 8-11 TA1B

Integrated Propulsion Technology Demonstrator

Task 2 - Assembly And Operation

ID	Description	Start	Finish	Milestone
131	2.1.19 AETF/IPTD Integration & Thrust Structure Design	1/3/97	7/30/97	
132	Submit AETF Thrust Structure Design	5/30/97	5/30/97	5/30
133	AETF/IPTD Integration Design Complete	7/30/97	7/30/97	7/30
134	**2.1.2 PCCS Design & Development**	**7/6/94**	**12/15/98**	
135	2.1.2.1 Phase 0 RI/MSFC PCCS Coordination	7/15/95	2/28/96	
136	2.1.2.2 Preliminary PCCS	9/1/94	12/15/94	
137	Team PCCS Technical Review At	1/15/95	1/15/95	1/15
138	2.1.2.3 Develop Preliminary System	12/5/95	2/28/96	
139	2.1.2.4 Establish Real-Time Sim.	1/4/95	2/28/95	
140	2.1.2.5 Document PCCS Phase 0	2/1/95	2/28/95	
141	Team Member Real-Time Interface	2/28/95	2/28/95	2/28
142	2.1.2.6 Phase 1 RI/NASA PCCS	3/1/95	12/22/95	
143	2.1.2.7 Assemble Engine Control	3/1/95	3/31/95	
144	2.1.2.8 Define Requirements For Partioned	4/3/95	5/1/95	

NRA 8-11 TA1B

Integrated Propulsion Technology Demonstrator

Task 2 - Assembly And Operation

ID	Description	Start	Finish
145	2.1.2.9 Identify HCF/PCCS Control	4/3/95	5/1/95
146	**2.1.2.12 Design/Assembl PCCS Control**	**3/1/95**	**6/5/95**
147	2.1.2.10 Update PCCS	3/1/95	6/5/95
148	2.1.2.11 Develop Propulsion	3/1/95	5/31/95
149	Team PCCS Specificati	6/5/95	6/5/95
150	2.1.2.12 Update Test Series 1 Propulsion	6/1/95	6/30/95
151	2.1.2.13 Build & Validate Test Series 1 PCCS	6/1/95	10/23/95
152	2.1.2.14 Integrate PCCS With HCF	11/1/95	12/22/95
153	Team PCCS Support Test Series 1 TRR	12/15/95	12/15/95
154	2.1.2.15 Document Phase 1 PCCS	11/29/95	12/22/95
155	2.1.2.16 Phase 2 RI/MSFC PCCS	1/4/96	11/27/96
156	2.1.2.2 Develop/Valida Modeling &	7/6/94	11/1/94
157	2.1.2.3 Perform FMEA Analysis	7/6/94	6/23/95
158	**2.1.2.4 Develop/Valida Distributed**	**1/3/96**	**11/27/96**

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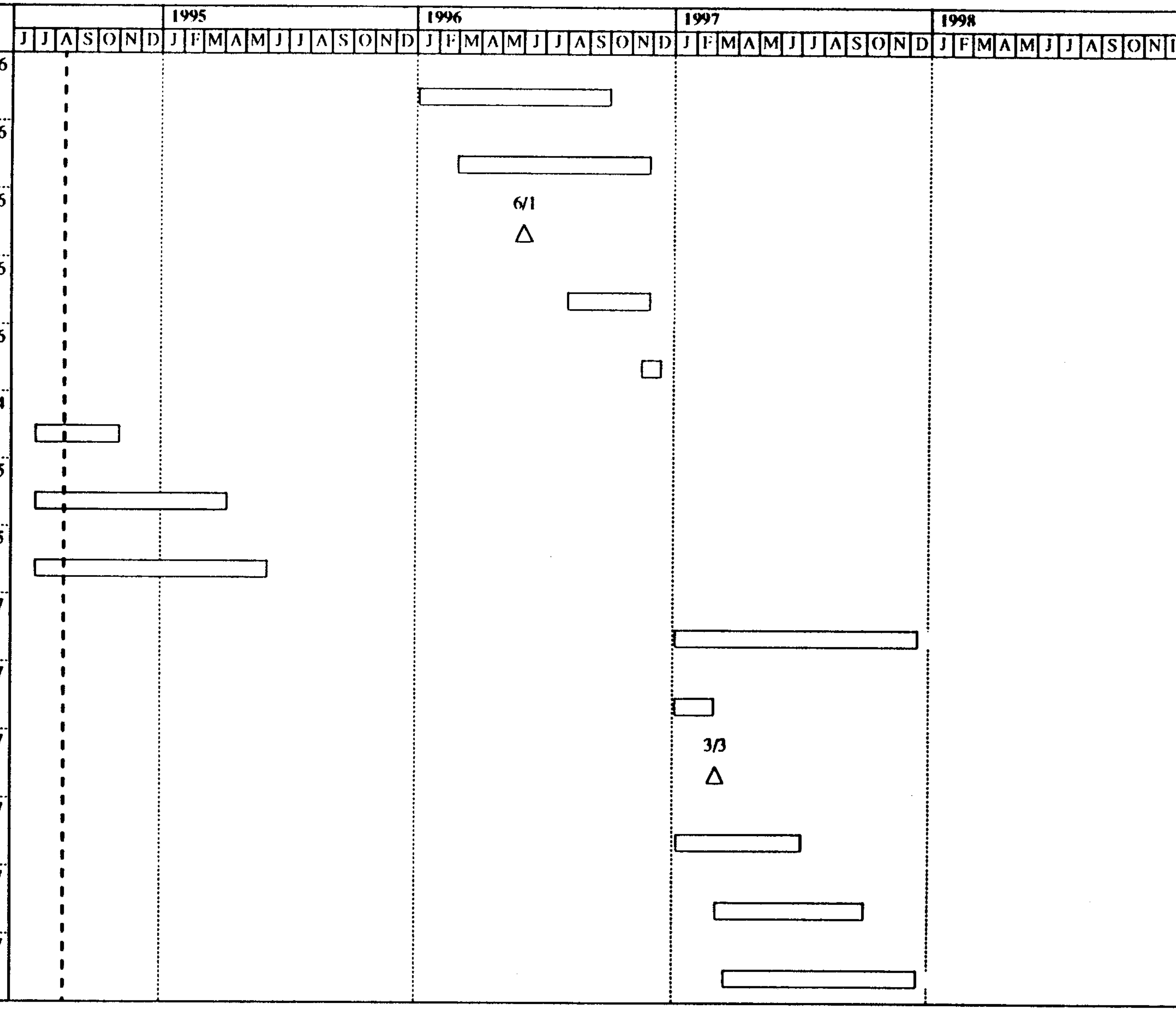
Integrated Propulsion Technology Demonstrator

Task 2 - Assembly And Operation

ID	Description	Start	Finish
159	2.1.2.17 Design/De\ Smart	1/3/96	9/30/96
160	2.1.2.18 Design/De\ Real-Time	2/28/96	11/27/96
161	Detailed Engine Control	6/1/96	6/1/96
162	2.1.2.19 Initiate Intelligent	8/1/96	11/27/96
163	2.1.2.20 Document Phase 2 PCCS	11/15/96	12/13/96
164	2.1.2.2 Develop/Validat Modeling &	7/6/94	11/2/94
165	2.1.2.3 Perform FMEA Analysis	7/6/94	4/5/95
166	2.1.2.4 Develop/Validat Distributed	7/6/94	6/2/95
167	2.1.2.21 Phase 3 RI/NASA PCCS	1/3/97	12/15/97
168	2.1.2.22 Integrate Updated PCCS	1/3/97	2/28/97
169	2.1.2.23 Team PCCS Support Test Series 2	3/3/97	3/3/97
170	2.1.2.24 Complete Smart Sensor	1/6/97	7/3/97
171	2.1.2.25 Complete Real-Time	3/3/97	10/1/97
172	2.1.2.26 Complete Intelligent	3/15/97	12/15/97

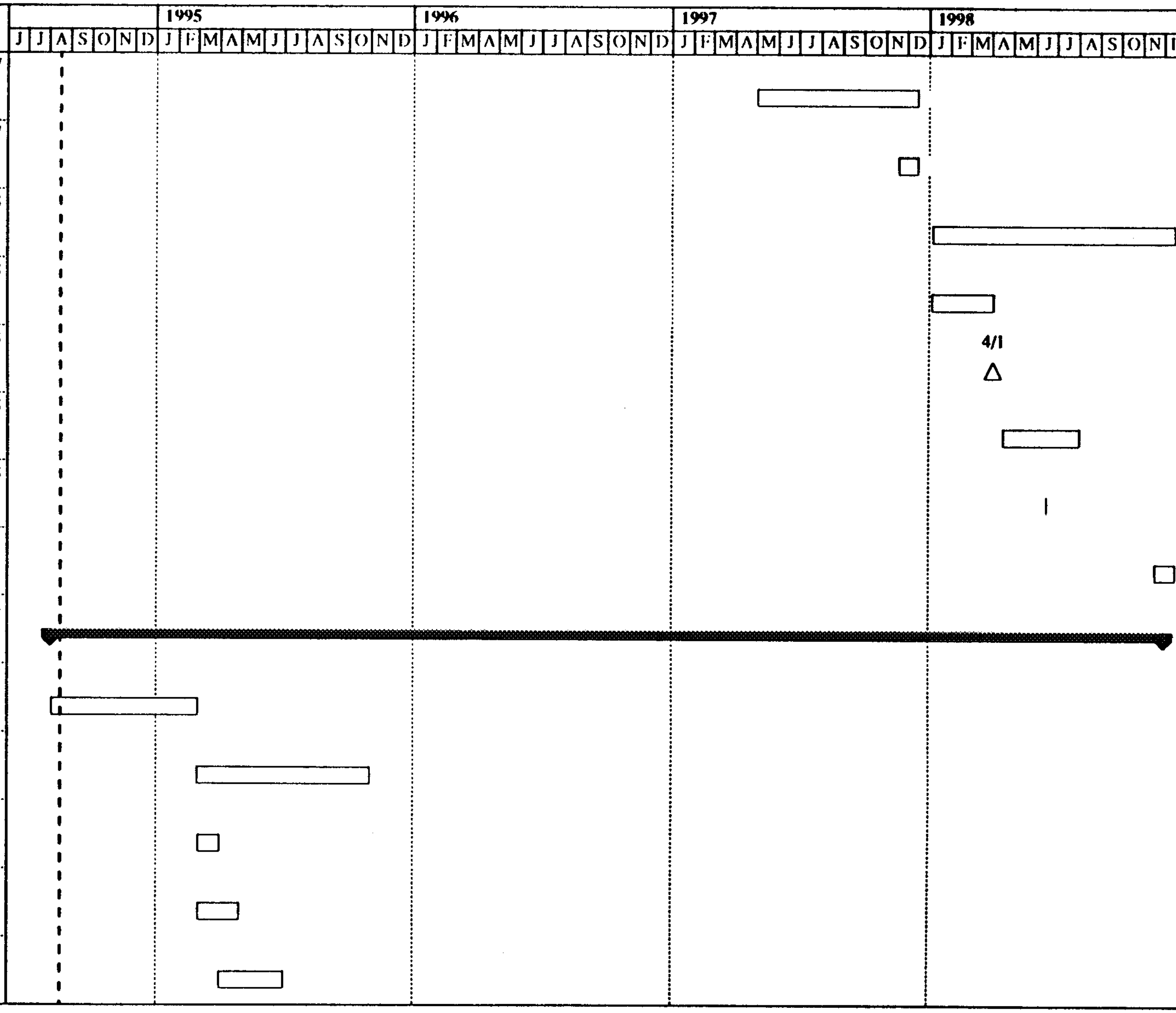


NRA 8-11 TA1B

Integrated Propulsion Technology Demonstrator

Task 2 - Assembly And Operation

ID	Description	Start	Finish
173	2.1.2.27 Initiate Engine Controller	5/1/97	12/15/97
174	2.1.2.28 Document Phase 3 PCCS	11/17/97	12/15/97
175	2.1.2.29 Phase 4 RI/MSFC PCCS	1/5/98	12/15/98
176	2.1.2.30 Complete Engine Control	1/3/98	4/1/98
177	Move PCCS From HCF To AETF	4/1/98	4/1/98
178	2.1.2.31 Test & Checkout PCCS On AETF	4/15/98	7/31/98
179	2.1.2.32 Team PCCS Support Test Series 4	6/15/98	6/15/98
180	2.1.2.33 Document Phase 4 PCCS	11/16/98	12/15/98
181	**Task 2.2 - IPTD Fabrication & Integration**	8/2/94	11/30/98
182	2.2.1 Procure Existing Flight Hardware &	8/2/94	2/28/95
183	2.2.2 Coordinate Phase 1 Production Operations	2/27/95	10/31/95
184	2.2.3 Fabricate HCF Pier Support Bridging Beams	3/1/95	3/31/95
185	2.2.4 Refurbish Shuttle Components	3/1/95	4/28/95
186	2.2.5 Fabricate Propulsion Module Structure	3/31/95	6/30/95



NRA 8-11 TA1B

Integrated Propulsion Technology Demonstrator

Task 2 - Assembly And Operation

ID	Description	Start	Finish
187	2.2.6 Fabricate And Integrate HCF Facility Mods	4/3/95	10/30/95
188	2.2.7 Fabricate IPTD Rotation & Lifting Adapters	4/3/95	4/28/95
189	2.2.8 Fabricate Fluid Lines & Support Brackets	5/10/95	7/31/95
190	2.2.9 Cryo-Shock & Proof Test Fluid Lines	5/30/95	7/31/95
191	2.2.10 Insulate Fluid Lines	6/29/95	7/31/95
192	2.2.11 Install Fluid Lines In Propulsion Module	6/29/95	8/30/95
193	2.2.12 Fabricate Fire-Ex System	8/1/95	8/30/95
194	2.2.13 Install Instrumentation & Patch Systems	8/15/95	10/17/95
195	2.2.14 Fabricate Haz-Gas Detection Systems	8/31/95	9/30/95
196	MSFC HCF Facility Required	9/6/95	12/19/97
197	2.2.15 Pccs Functional Checkout	9/15/95	10/24/95
198	2.2.16 Ship Propulsion Module	10/24/95	10/31/95
199	Ship Propulsion Module	11/1/95	11/1/95
200	2.2.17 Integrate Propulsion Module At HCF	11/1/95	1/2/96

1995 1996 1997 1998

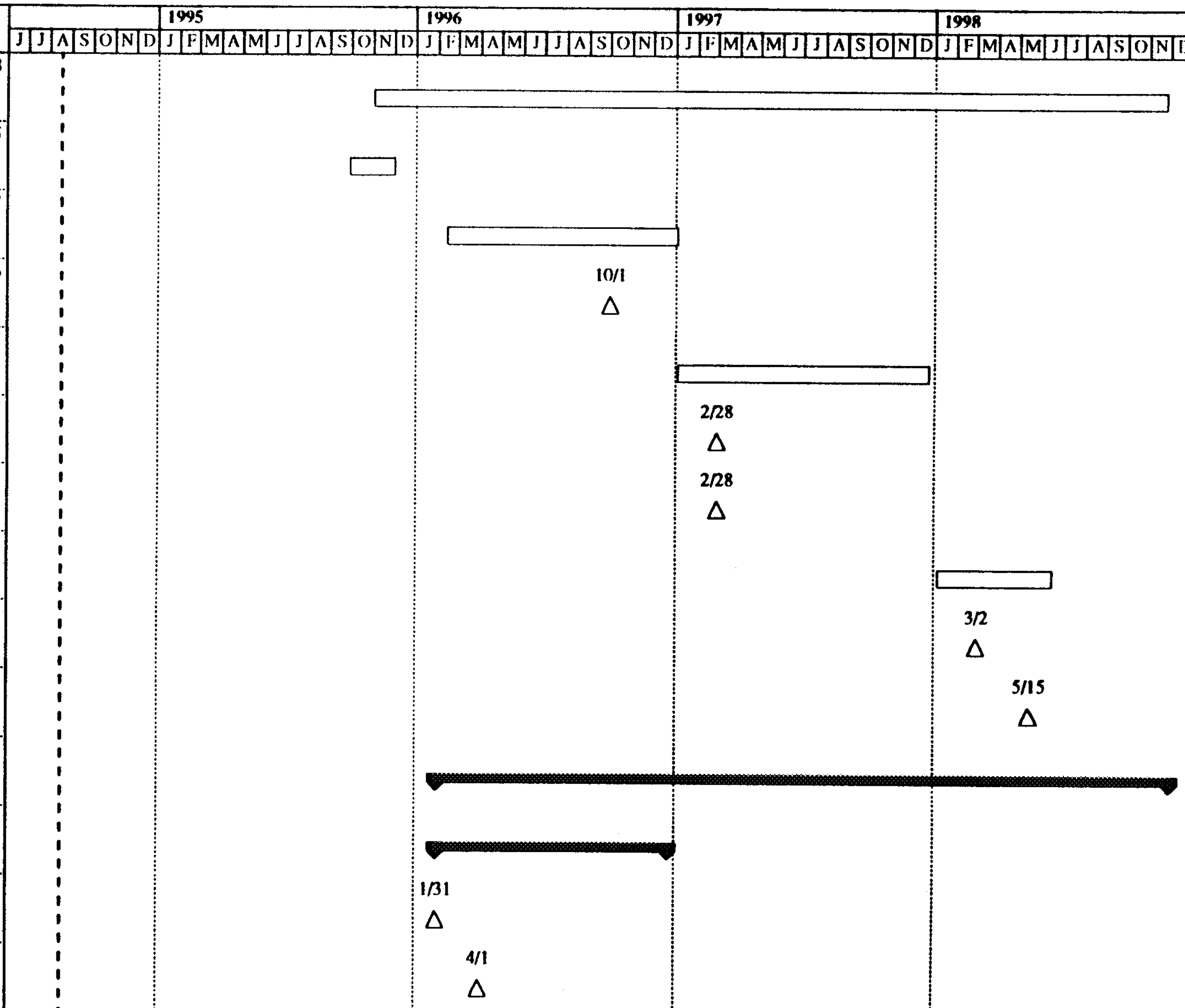
11/1

NRA 8-11 TA1B

Integrated Propulsion Technology Demonstrator

Task 2 - Assembly And Operation

ID	Description	Start	Finish
201	MSFC Bldg 4653 Service/Repair Facility Required	11/1/95	11/24/98
203	2.2.18 Procure Components & Valves For Phase 2	9/28/95	11/30/95
204	2.2.19 Fabricate & Integrate Mods To The IPTD	2/13/96	1/3/97
205	Ship LH2 & LO2 Modules	10/1/96	10/1/96
206	2.2.20 Fabricate AETF Thrust Structure & Integr	1/3/97	12/23/97
207	Ship Sub Systems Module	2/28/97	2/28/97
208	Ts # 2 Test Readiness Review	2/28/97	2/28/97
209	2.2.21 Integrate IPTD & Thrust Structure In AETF	1/5/98	6/15/98
211	Ship AETF Integration Hardware	3/2/98	3/2/98
212	Ts # 3 Test Readiness Review	5/15/98	5/15/98
213	**Task 2.3 - Perform Test Operations**	**1/31/96**	**11/30/98**
214	**2.3.1 Conduct Boat Tail Integ. Test**	**1/31/96**	**12/23/96**
215	Interim Test Status 20% Test	1/31/96	1/31/96
216	Interim Test Status 80% Test	4/1/96	4/1/96



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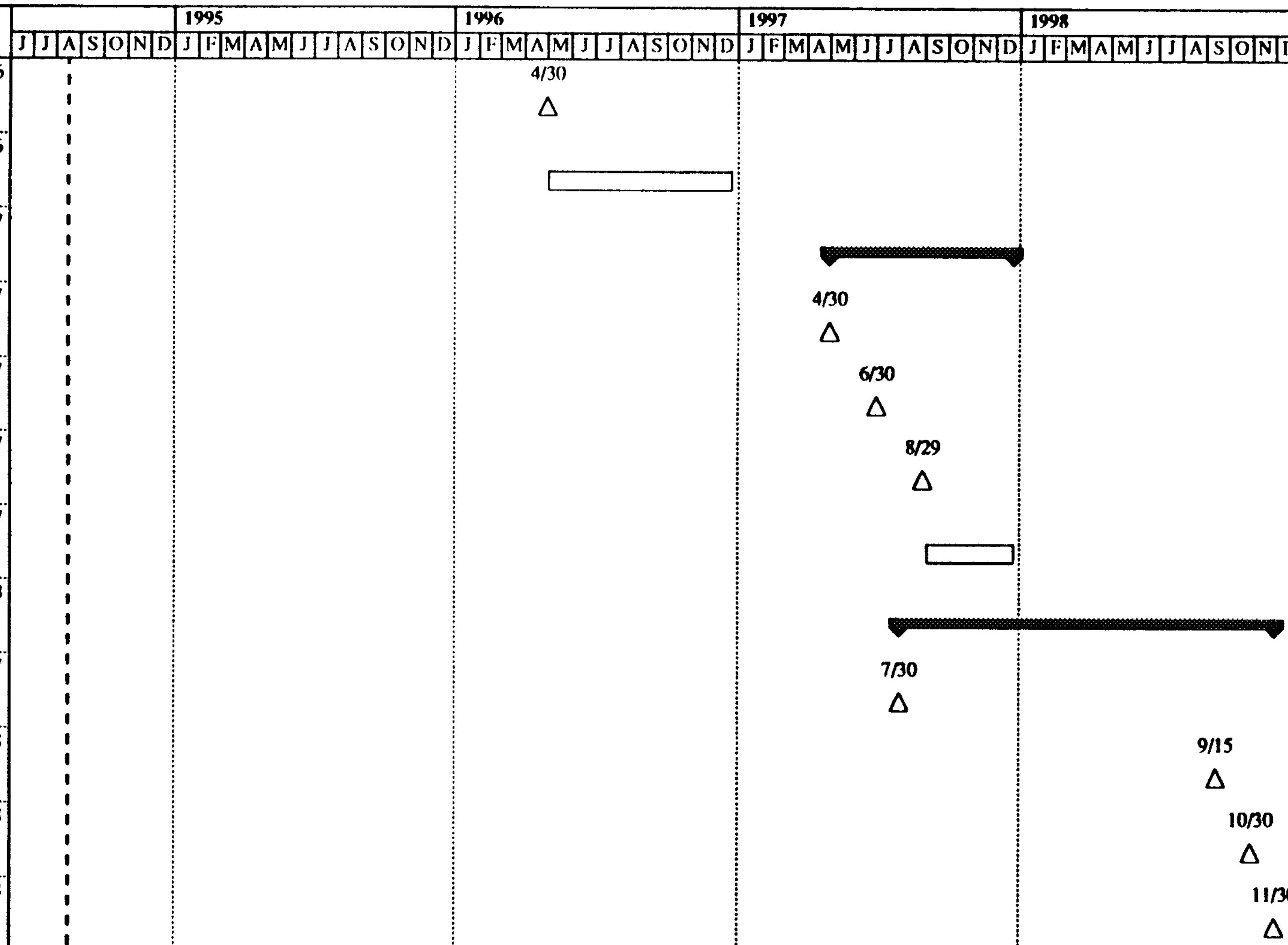
Integrated Propulsion Technology Demonstrator

Task 2 - Assembly And Operation

ID	Description	Start	Finish
217	Test Sequence 1 Data	4/30/96	4/30/96
218	2.3 Test Seq. 1 Test Options	5/1/96	12/23/96
219	**2.3.2 Conduct Tri Propellent Integ. Cold**	**4/30/97**	**12/23/97**
220	Interim Test Status 20% Test	4/30/97	4/30/97
221	Interim Test Status 80% Test	6/30/97	6/30/97
222	Test Sequence 2 Data	8/29/97	8/29/97
223	2.3 Test Seq. 2 Test Options	9/2/97	12/23/97
224	**2.3.3 Conduct Integrated Engine Sys.**	**7/30/97**	**11/30/98**
225	Interim Test Status 20% Test	7/30/97	7/30/97
226	Interim Test Status 60% Test	9/15/98	9/15/98
227	Interim Test Status 80% Test	10/30/98	10/30/98
228	Test Sequence 3 Data	11/30/98	11/30/98



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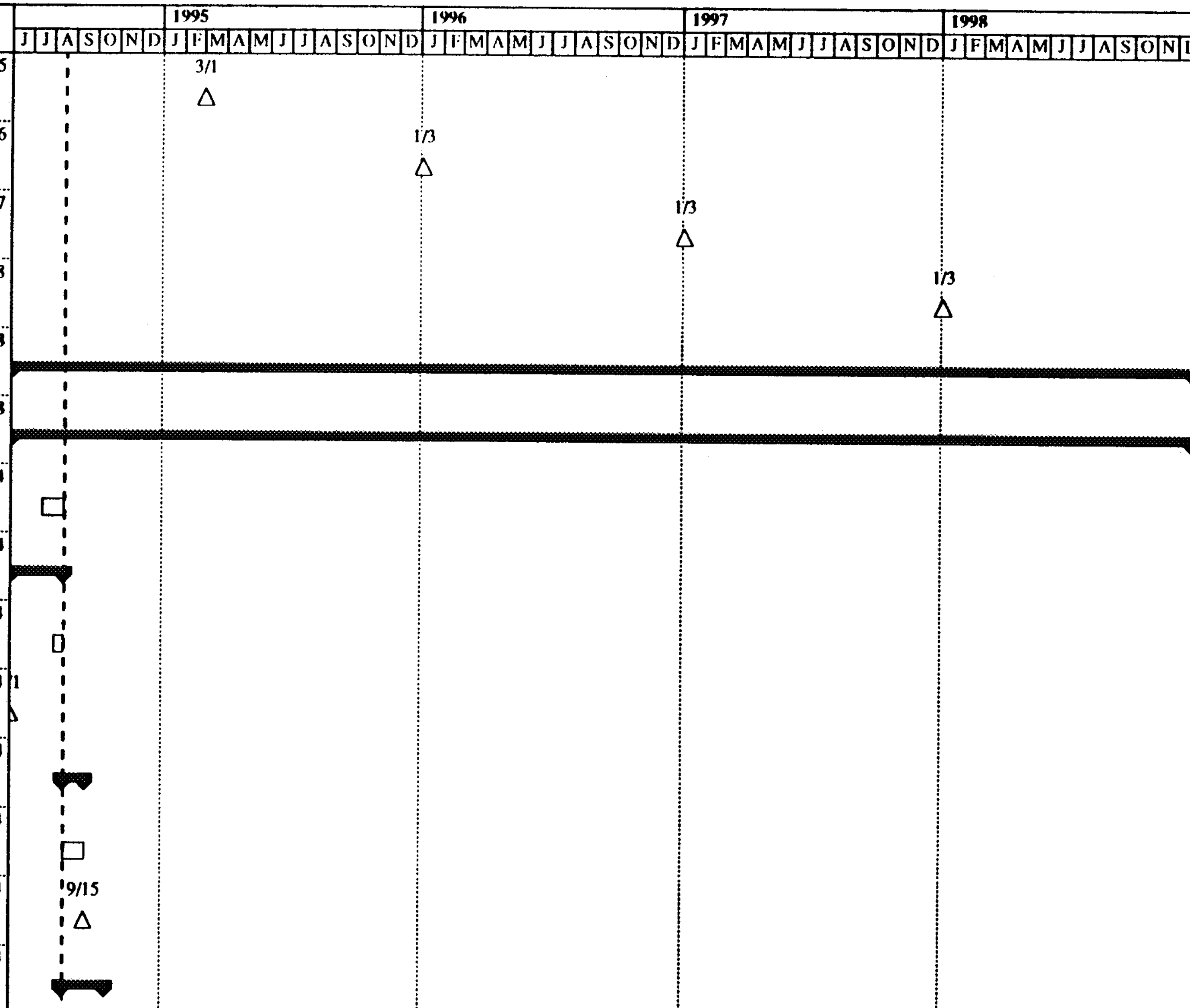
Integrated Propulsion Technology Demonstrator

Task 3 - Data Analysis And Utilization

ID	Description	Start	Finish
11	Initiate Phase 1 (Boat Tail Design & Fab.)	3/1/95	3/1/95
19	Initiate Phase 2 (Boat Tail Integ. Tests & Tank Fab.)	1/3/96	1/3/96
31	Initiate Phase 3 (Tri-Propellent Integ. Cold Flow Test)	1/3/97	1/3/97
43	Initiate Phase 4 (Integrated Engine Sys. Test)	1/3/98	1/3/98
229	**Task 3 - Data Analysis & Utilization**	**6/1/94**	**12/23/98**
230	**3.1 Update Models & Algorithms**	**6/1/94**	**12/20/98**
231	3.1.1 Participate In Preparation Of Plan Of Action	7/15/94	8/15/94
232	**3.1.2 Form PDT**	**6/1/94**	**8/15/94**
233	3.1.2.1 Coordinate With	8/1/94	8/15/94
234	3.1.2.2 PDT Established.	6/1/94	6/1/94
235	**3.1.3 Develop Recommended IPTD Demo Reqmts**	**8/15/94**	**9/15/94**
236	3.1.3.1 Develop Recommended IPTD Demo	8/15/94	9/15/94
237	3.1.3.2 Recommended Demo's	9/15/94	9/15/94
238	**3.1.4 Describe Baseline Set Of Models**	**8/15/94**	**10/15/94**



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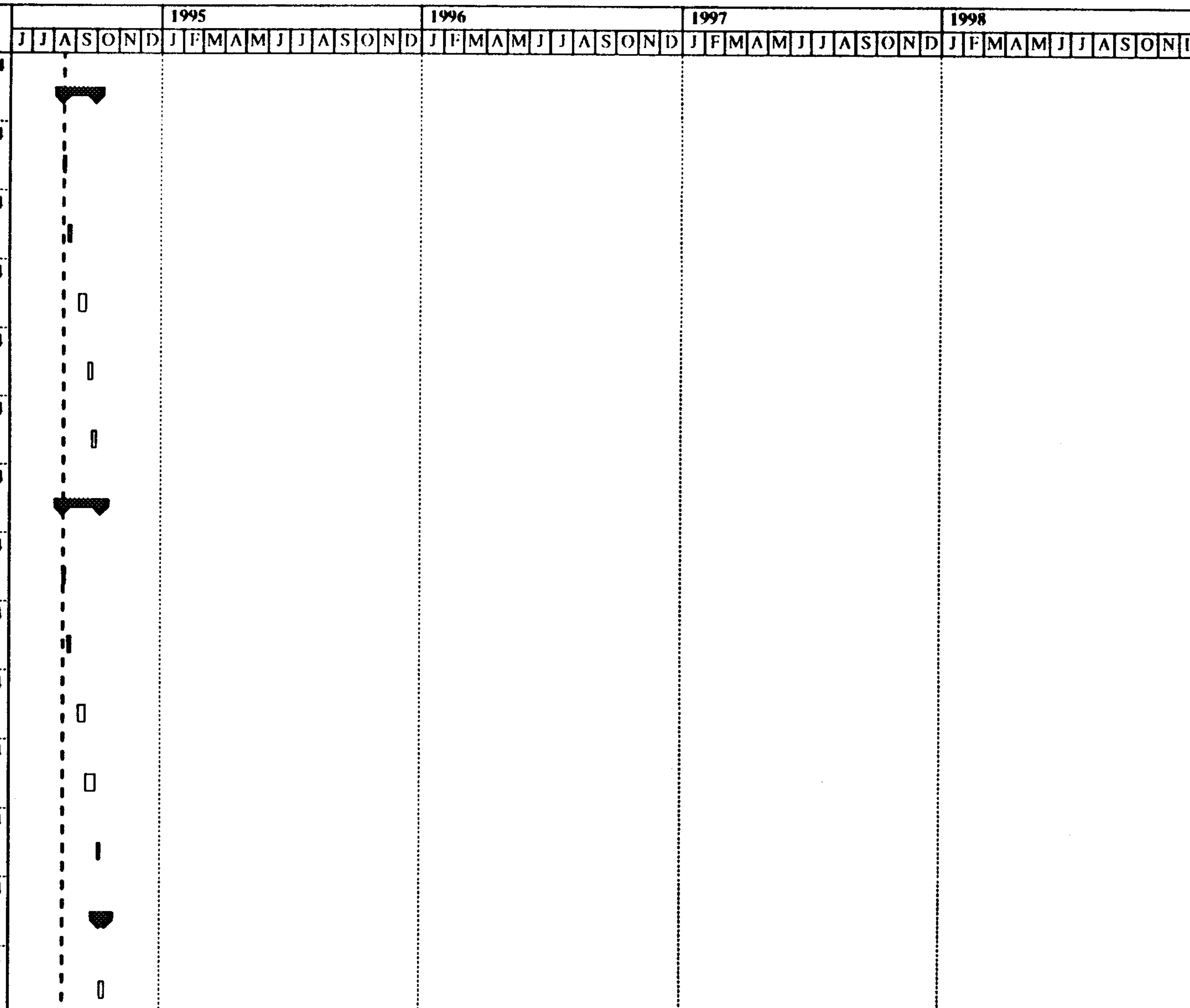
Integrated Propulsion Technology Demonstrator

Task 3 - Data Analysis And Utilization

ID	Description	Start	Finish
239	**3.1.4.1 Describe Baseline Set Of**	**8/15/94**	**9/30/94**
240	3.1.4.1.1 Define Reqmts	8/15/94	8/19/94
241	3.1.4.1.2 Select Set Of Ops	8/22/94	8/26/94
242	3.1.4.1.3 Prepare Draft	9/6/94	9/16/94
243	3.1.4.1.4 Conduct PDT	9/19/94	9/25/94
244	3.1.4.1.5 Finalize Ops Input	9/25/94	9/30/94
245	**3.1.4.2 Describe Baseline Set Of**	**8/15/94**	**10/7/94**
246	3.1.4.2.1 Define Reqmts	8/15/94	8/19/94
247	3.1.4.2.2 Select Set Of	8/22/94	8/26/94
248	3.1.4.2.3 Prepare Draft	9/6/94	9/16/94
249	3.1.4.2.4 Conduct PDT	9/17/94	9/30/94
250	3.1.4.2.5 inalize Fluid/Then	10/3/94	10/7/94
251	**3.1.4.3 Prepare Combined Submittal**	**10/7/94**	**10/15/94**
252	3.1.4.3.1 Combine Ops &	10/7/94	10/14/94



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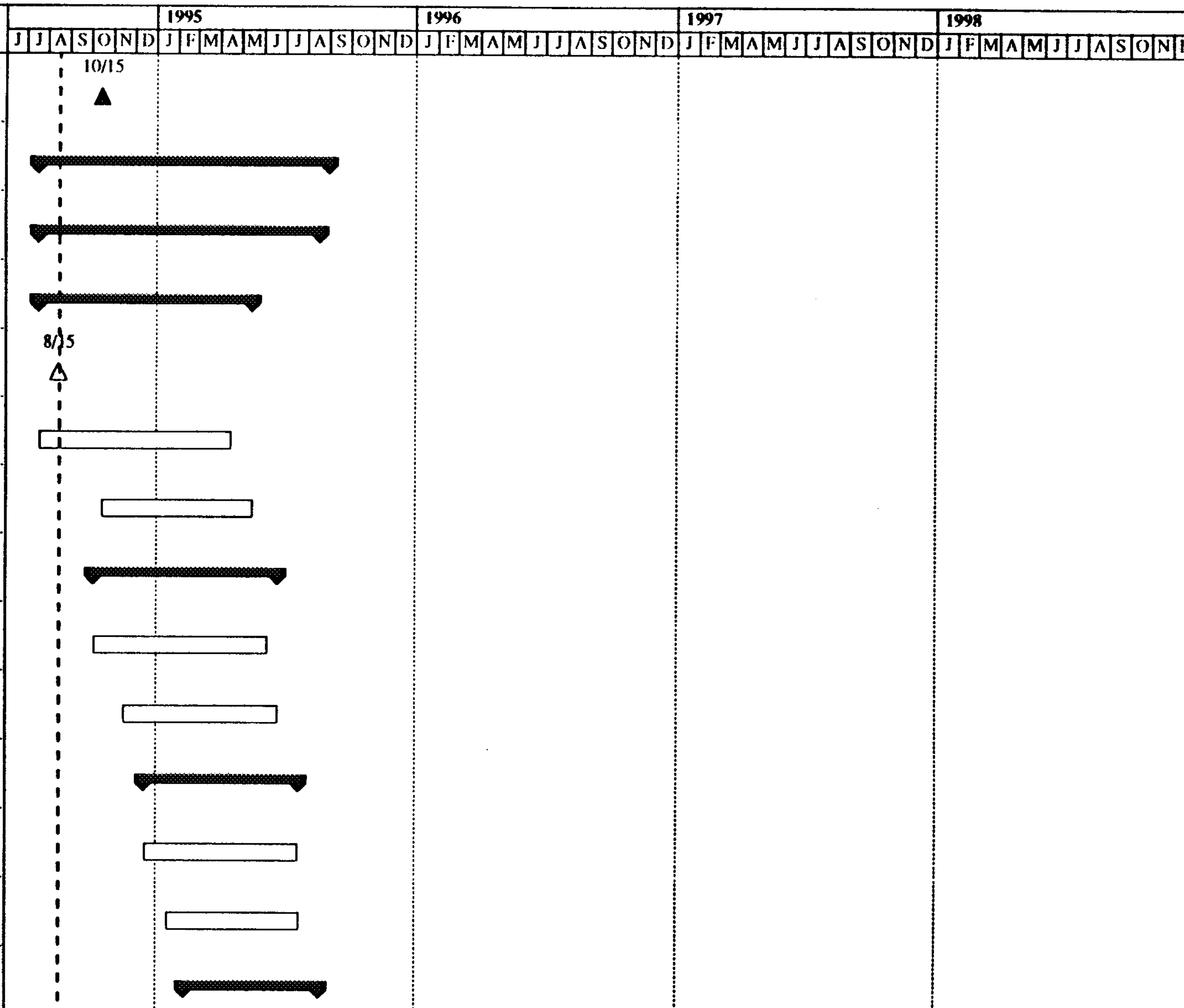
Integrated Propulsion Technology Demonstrator

Task 3 - Data Analysis And Utilization

ID	Description	Start	Finish
253	3.1.4.3.2 Baseline Models	10/15/94	10/15/94
254	**3.1.5 Adapt Models To IPTD Configuration**	**7/18/94**	**8/31/95**
255	**3.1.5.1 Adapt Operations Models To**	**7/18/94**	**8/18/95**
256	**3.1.5.1.1 Establish Shuttle**	**7/18/94**	**5/15/95**
257	3.1.5. Task Updat	8/15/94	8/15/94
258	3.1.5. Dev. End	7/18/94	4/15/95
259	3.1.5. Dev. MPS	10/15/94	5/15/95
260	**3.1.5.1.2 Dev. Shuttle-St**	**10/4/94**	**6/20/95**
261	3.1.5. End To	10/4/94	6/5/95
262	3.1.5. MPS Detail	11/15/94	6/20/95
263	**3.1.5.1.3 Develop Airline-St**	**12/15/94**	**7/20/95**
264	3.1.5. End To	12/15/94	7/18/95
265	3.1.5. MPS Detail	1/16/95	7/20/95
266	**3.1.5.1.4 Develop SSTO**	**2/10/95**	**8/18/95**



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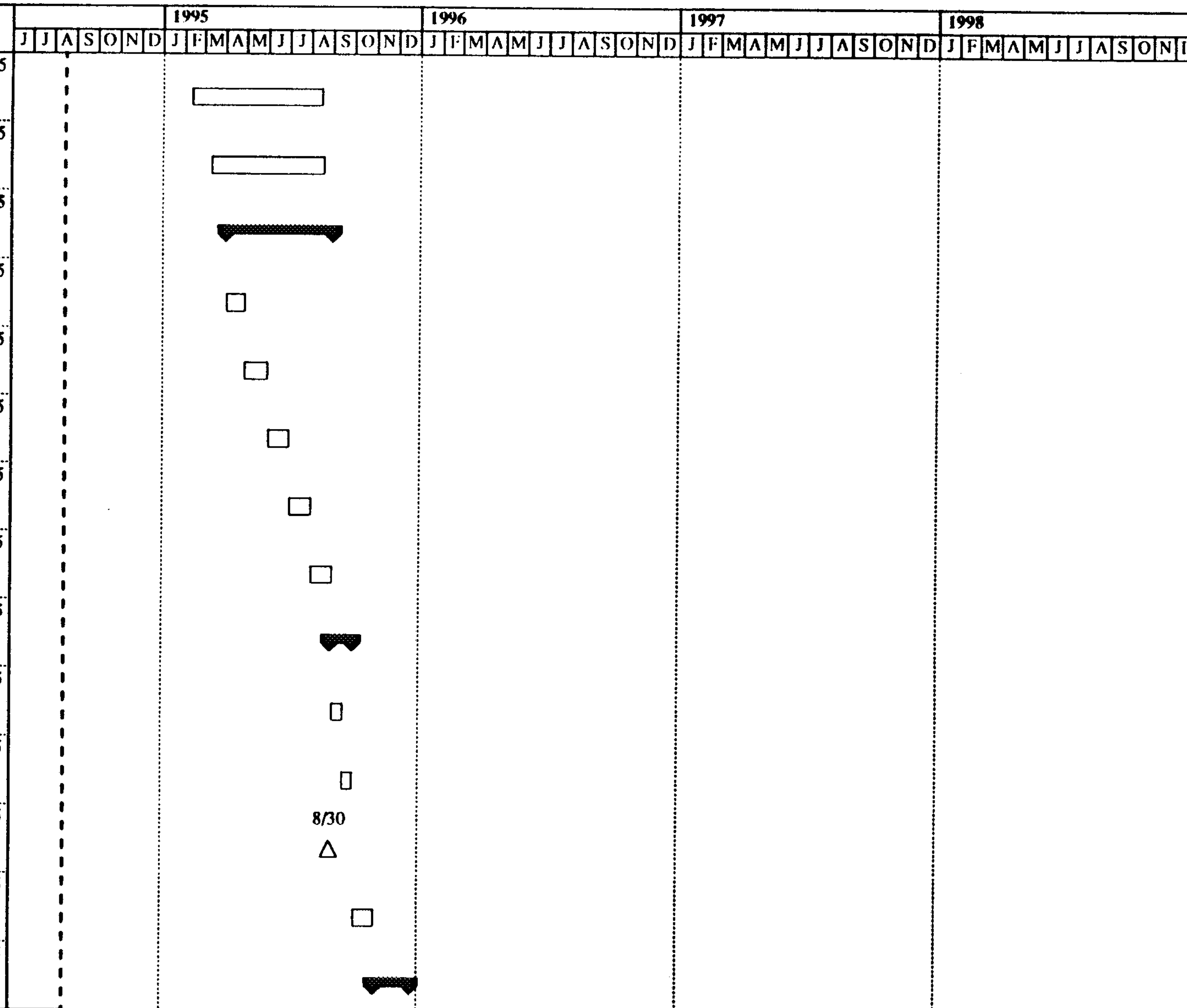
Integrated Propulsion Technology Demonstrator

Task 3 - Data Analysis And Utilization

ID	Description	Start	Finish
267	3.1.5. End To	2/10/95	8/15/95
268	3.1.5. MPS Detail	3/10/95	8/18/95
269	**3.1.5.2 Adapt Fluid/Thermal Models To**	**4/1/95**	**8/31/95**
270	3.1.5.2.1 MPS Pressurizati	4/1/95	4/28/95
271	3.1.5.2.2 MPS Feed System	4/28/95	5/31/95
272	3.1.5.2.3 MPS Propellant	6/1/95	6/30/95
273	3.1.5.2.4 Passive, No-Bleed,	7/1/95	8/1/95
274	3.1.5.2.5 Main Propulsion	8/1/95	8/31/95
275	**3.1.6 Predict IPTD Operations & Fluid/Thermal**	**8/30/95**	**9/30/95**
276	3.1.6.1 Predict Key Full Scale Operations	8/31/95	9/15/95
277	3.1.6.2 Predict Key Full Scale Fluid/Thermal	9/15/95	9/30/95
278	3.1.6.3 Ops & Perf Predictions Submitted To	8/30/95	8/30/95
279	3.1.7 Prep. Recommended Demo. & Meas.	10/2/95	10/31/95
280	**3.1.8 Predict Test Seq. 1 Measurement Values**	**11/1/95**	**12/22/95**



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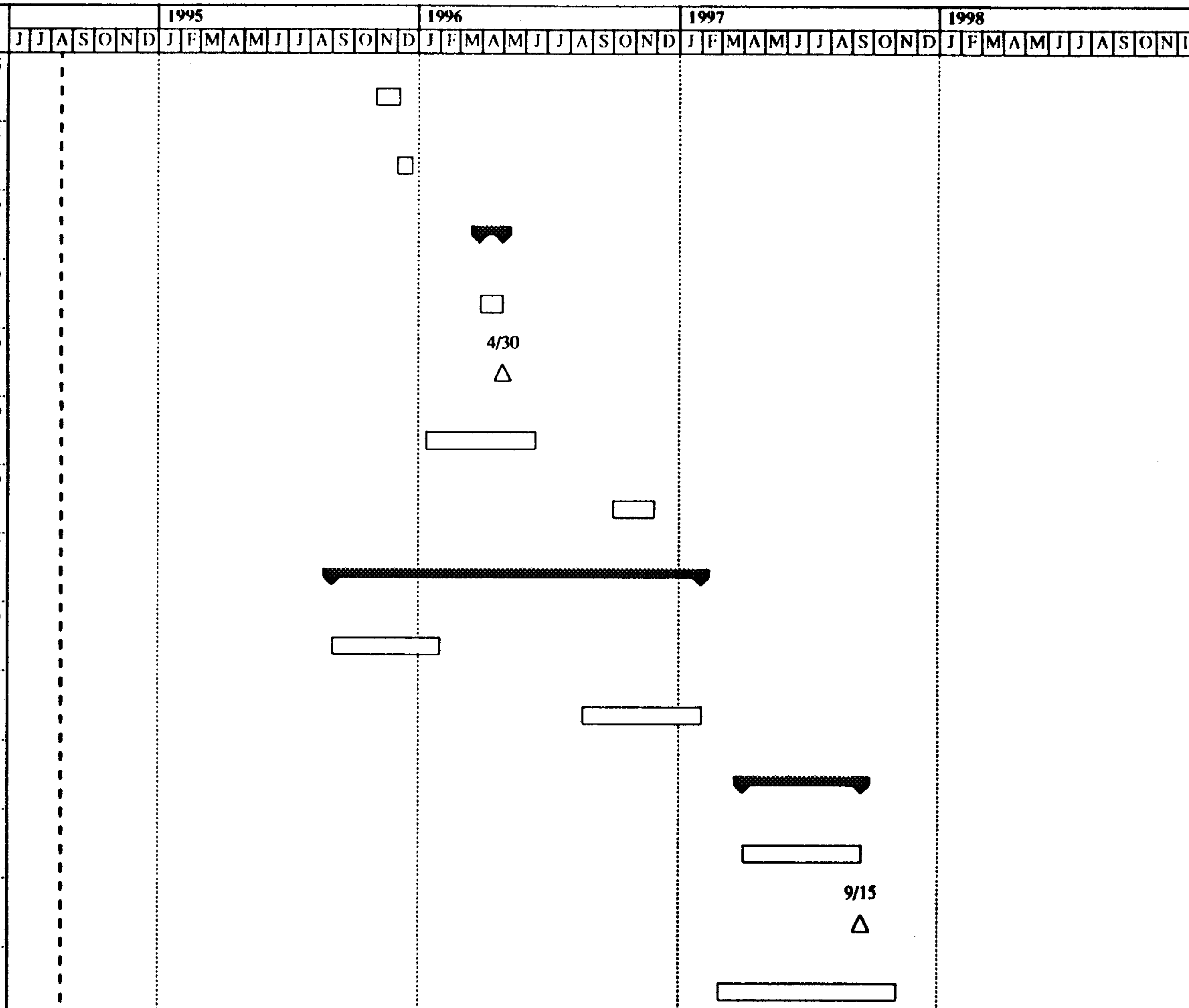
Integrated Propulsion Technology Demonstrator

Task 3 - Data Analysis And Utilization

ID	Description	Start	Finish
281	3.1.8.1 Operations Measurement	11/1/95	12/4/95
282	3.1.8.2 Perf./Eng Meas. Values	12/1/95	12/22/95
283	**3.1.9 Review Test Sequence 1 Data**	**3/29/96**	**4/30/96**
284	3.1.9.1 Conduct Review	3/29/96	4/30/96
285	3.1.9.2 TS 1 Data Review Submitted To	4/30/96	4/30/96
286	3.1.10 Update Models Based On TS-1 Data	1/11/96	6/14/96
287	3.1.11 Prep. Recommended Demo. & Meas.	9/30/96	11/27/96
288	**3.1.12 Predict Test Seq. 2 Measurement Values**	**9/1/95**	**1/31/97**
289	3.1.12.1 Operations Measurement	9/1/95	1/31/96
290	3.1.12.2 Fluid/Thermal Meas. Values	8/19/96	1/31/97
291	**3.1.13 Review Test Sequence 2 Data**	**4/1/97**	**9/15/97**
292	3.1.13.1 Conduct Review	4/1/97	9/15/97
293	3.1.13.2 TS 2 Data Review Submitted To	9/15/97	9/15/97
294	3.1.14 Update Models Based On TS-2 Data	2/25/97	11/3/97



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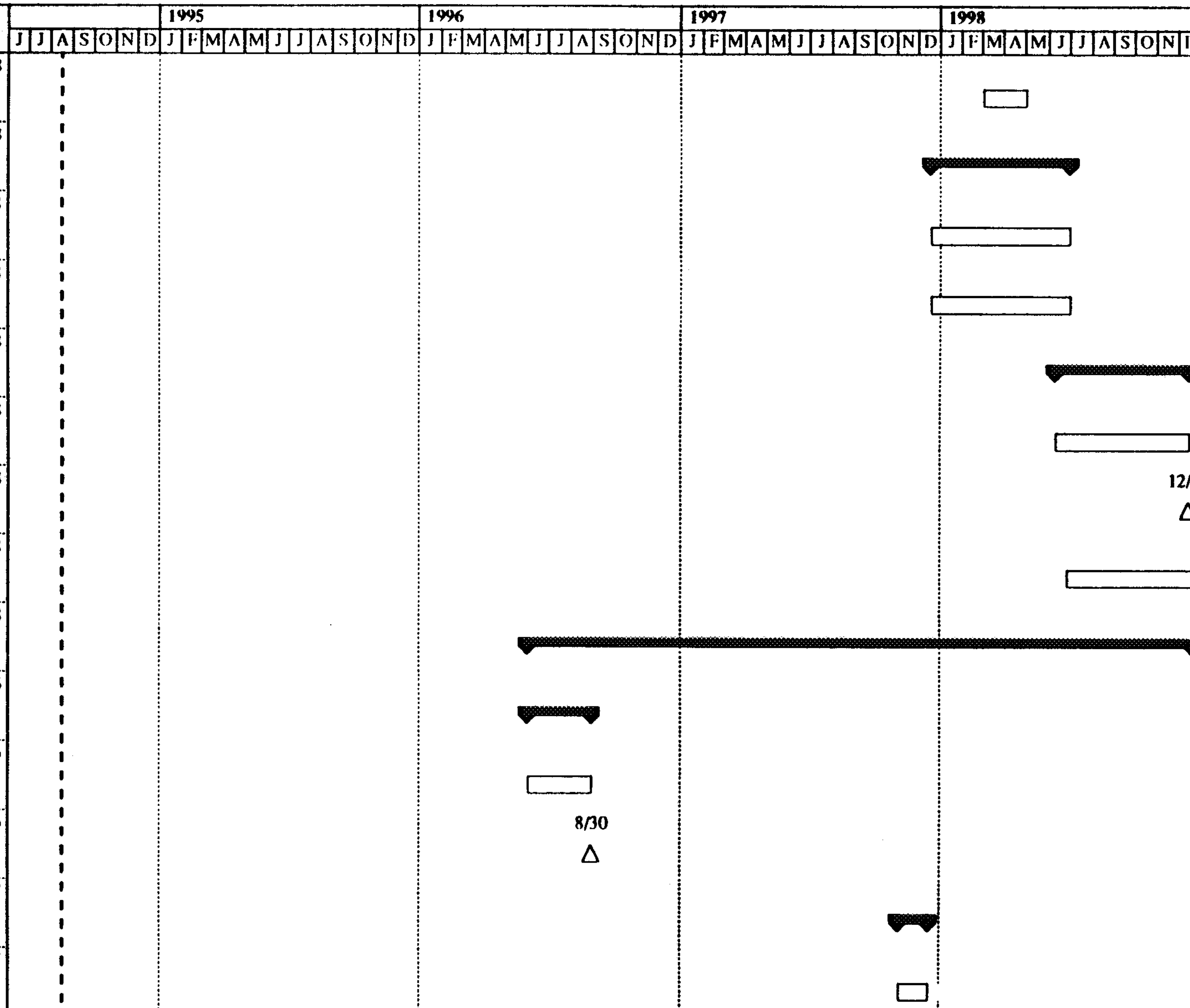
Integrated Propulsion Technology Demonstrator

Task 3 - Data Analysis And Utilization

ID	Description	Start	Finish
295	3.1.15 Prep. Recommended Demo. & Meas.	3/2/98	5/1/98
296	**3.1.16 Predict Test Seq 3 Measurement Values**	**12/18/97**	**6/30/98**
297	3.1.16.1 Operations Measurement	12/18/97	6/30/98
298	3.1.16.2 Fluid/Thermal Meas. Values	12/18/97	6/30/98
299	**3.1.17 Review Test Sequence 3 Data**	**6/9/98**	**12/15/98**
300	3.1.17.1 Conduct Review	6/9/98	12/15/98
301	3.1.17.2 TS 3 Data Review Submitted To	12/15/98	12/15/98
302	3.1.18 Update Models Based On TS-3 Data	6/25/98	12/20/98
303	**3.2 Extrapolate To Full Scale**	**6/1/96**	**12/20/98**
304	**3.2.1 Extrap.To Full Scale Based On Test Seq. 1 Data**	**6/1/96**	**8/30/96**
305	3.2.1.1 Perform Extrapolation	6/1/96	8/30/96
306	3.2.1.2 Test Seq 1 Extrapolation Completed	8/30/96	8/30/96
307	**3.2.2 Extrap.To Full Scale Based On Test Seq. 2 Data**	**11/3/97**	**12/15/97**
308	3.2.2.1 Perform Extrapolation	11/3/97	12/15/97



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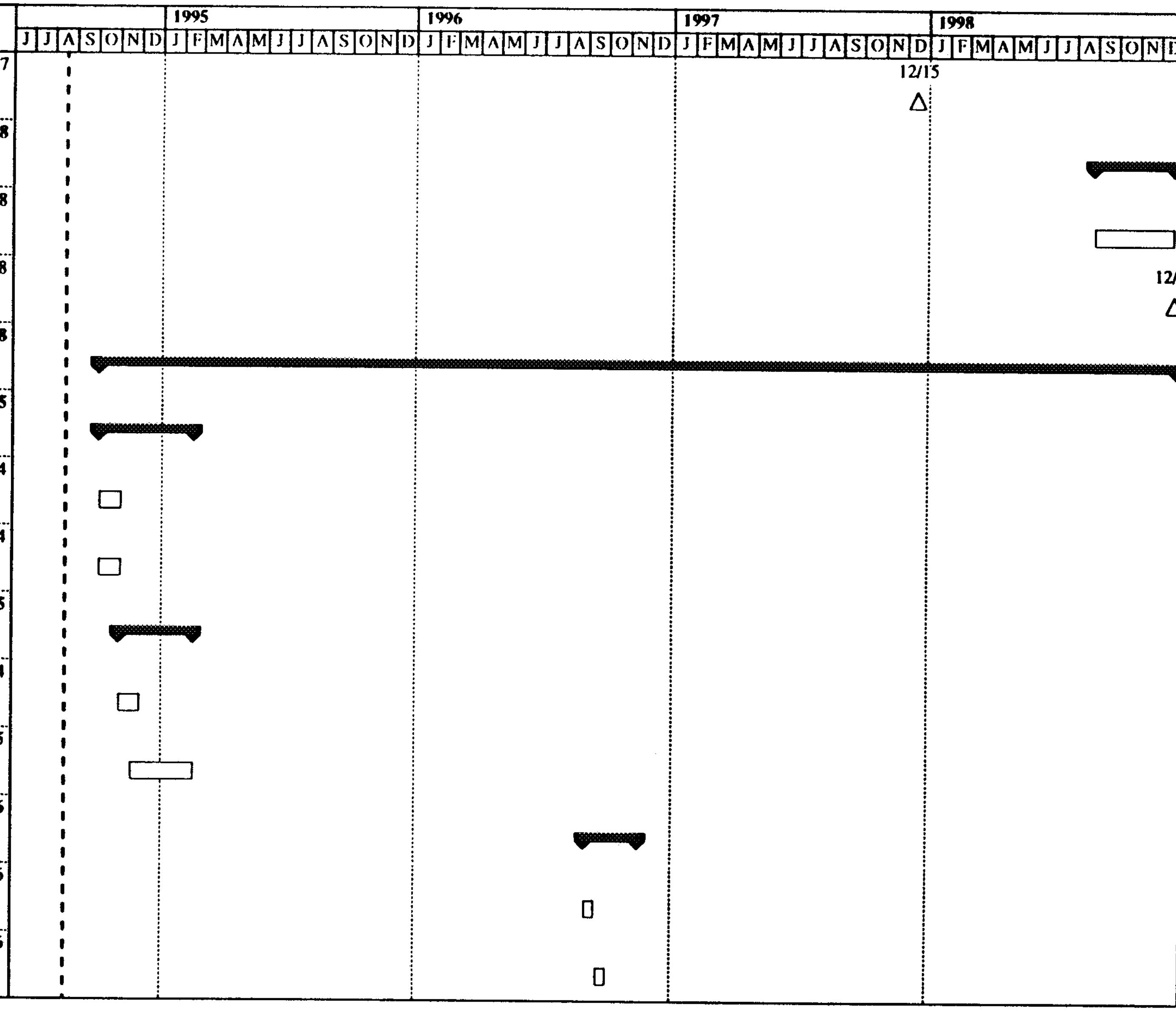
Integrated Propulsion Technology Demonstrator

Task 3 - Data Analysis And Utilization

ID	Description	Start	Finish
309	3.2.2.2 Test Seq 2 Extrapolation Completed	12/15/97	12/15/97
310	**3.2.3 Extrap.To Full Scale Based On Test Seq. 3 Data**	**8/27/98**	**12/20/98**
311	3.2.3.1 Perform Extrapolation	8/27/98	12/18/98
312	3.2.3.2 Test Seq 3 Extrapolation Completed	12/20/98	12/20/98
313	**3.3 Establish & Update Full Scale SSTO System Definition**	**10/3/94**	**12/23/98**
314	**3.3.1 Establish Prelim Full Scale SSTO Ref System**	**10/3/94**	**2/15/95**
315	3.3.1.1 System Reqmts/Vehicle Config/Sub Sys	10/3/94	11/3/94
316	3.3.1.2 Max Available Definition of	10/3/94	11/3/94
317	**3.3.1.3 Operations Concept**	**11/1/94**	**2/15/95**
318	3.3.1.3.1 System Top-Level	11/1/94	11/30/94
319	3.3.1.3.2 MPS Max Possible	11/18/94	2/15/95
320	**3.3.2 Update SSTO Ref System Def Based On TS-1**	**8/30/96**	**11/15/96**
321	3.3.2.1 System Reqmts/Vehicle Config/Sub Sys	8/30/96	9/13/96
322	3.3.2.2 Max Available Definition of	9/16/96	9/30/96



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Integrated Propulsion Technology Demonstrator

Task 3 - Data Analysis And Utilization

ID	Description	Start	Finish
323	3.3.2.3 Operations Concept	9/30/96	11/1/96
324	3.3.2.3.1 System Top-Level	9/30/96	10/8/96
325	3.3.2.3.2 MPS Max Possible	10/8/96	11/1/96
326	3.3.2.4 Recommended MPS Reqmts &	11/1/96	11/15/96
327	**3.3.3 Update Ref SSTO System Def Based On TS-2**	11/1/97	12/23/97
328	3.3.3.1 System Reqmts/Vehicle Config/Sub Sys	11/1/97	11/14/97
329	3.3.3.2 Max Available Definition of	11/15/97	12/3/97
330	3.3.3.3 Operations Concept	12/1/97	12/23/97
331	3.3.3.3.1 System Top-Level	12/1/97	12/10/97
332	3.3.3.3.2 MPS Max Possible	12/10/97	12/23/97
333	3.3.3.4 Recommended MPS Reqmts &	12/10/97	12/23/97
334	**3.3.4 Update Ref SSTO System Def Based On TS-3**	11/2/98	12/23/98
335	3.3.4.1 System Reqmts/Vehicle Config/Sub Sys	11/2/98	11/16/98
336	3.3.4.2 Max Available Definition of	11/2/98	11/16/98

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Integrated Propulsion Technology Demonstrator

Task 3 - Data Analysis And Utilization

ID	Description	Start	Finish
337	3.3.4.3 Operations Concept	11/15/98	12/21/98
338	3.3.4.3.1 System Top-Level	11/15/98	11/25/98
339	3.3.4.3.2 MPS Max Possible	11/30/98	12/21/98
340	3.3.4.4 Recommended MPS Reqmts &	12/20/98	12/23/98

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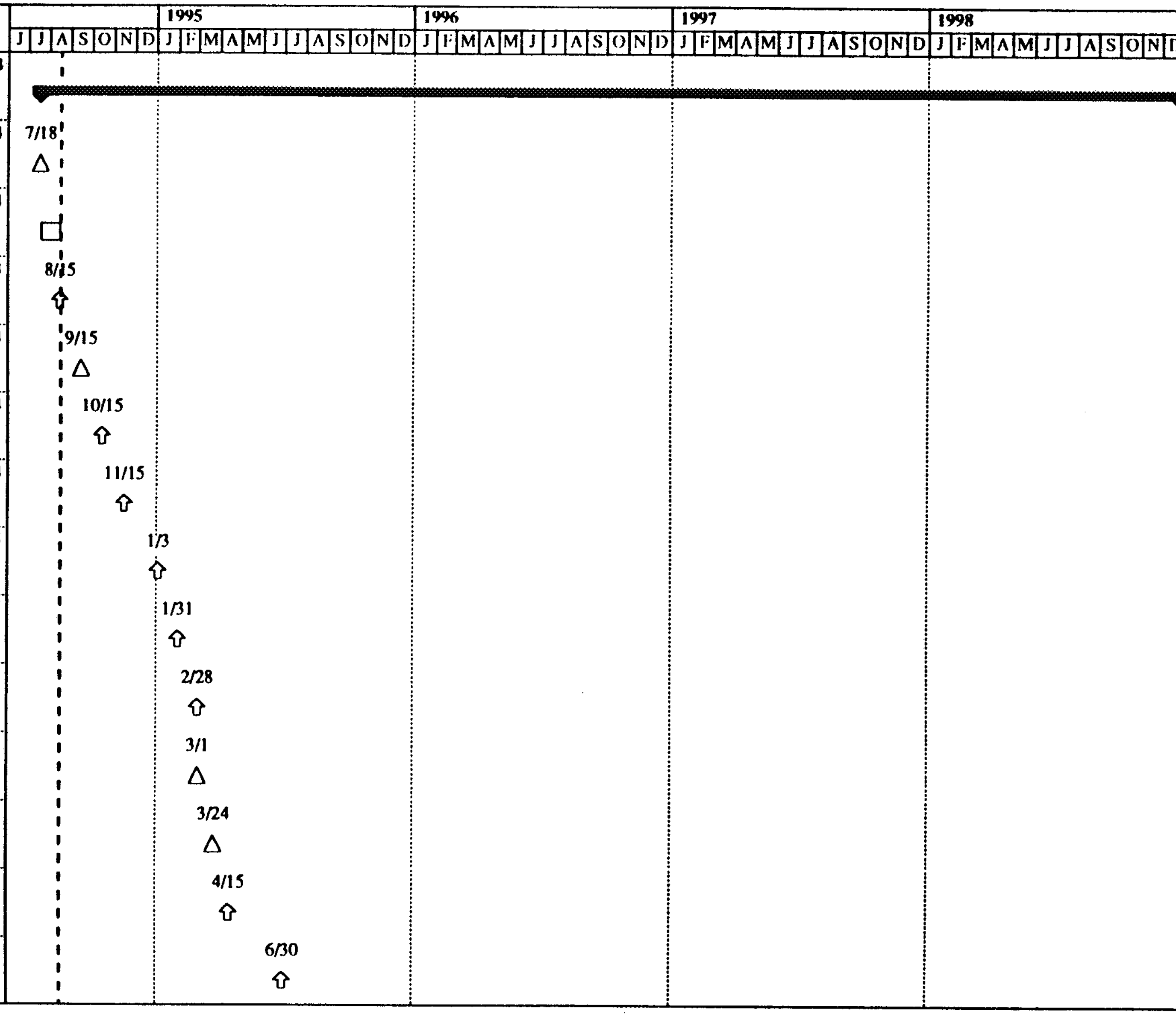
Integrated Propulsion Technology Demonstrator

Task 4 - Program Management

ID	Description	Start	Finish
1	Task 4 - Program Management	7/18/94	12/23/98
2	ATP	7/18/94	7/18/94
3	Develop Program Plan	7/18/94	8/15/94
4	Submit Draft Program Plan	8/15/94	8/15/94
5	Signoff Program Plan	9/15/94	9/15/94
6	Submit Description Of Ops & Performance Models	10/15/94	10/15/94
7	Submit Test Objective Definitions	11/15/94	11/15/94
8	Submit Cold Flow Pier Support Design Requirements	1/3/95	1/3/95
9	Draft Test Plan Established	1/31/95	1/31/95
10	Submit Draft Report - Basic Phase	2/28/95	2/28/95
11	Initiate Phase 1 (Boat Tail Design & Fab.)	3/1/95	3/1/95
12	Update Program Plan for Phase 1	3/24/95	3/24/95
13	Prop. Module Design Review(50% Complete)	4/15/95	4/15/95
14	Submit Propulsion Module Design Drawings	6/30/95	6/30/95



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Integrated Propulsion Technology Demonstrator

Task 4 - Program Management

ID	Description	Start	Finish	Milestone
15	Complete Phase 1 Ops & Performance Prediction	8/30/95	8/30/95	8/30
16	Ship Propulsion Module To MSFC	10/31/95	10/31/95	10/31
17	Draft Test Sequence 1 Test Objectives Draft Report	11/30/95	11/30/95	11/30
18	Test Sequence (TS) # 1 Test Readiness Review	12/22/95	12/22/95	12/22
19	Initiate Phase 2 (Boat Tail Integ. Tests & Tank Fab.)	1/3/96	1/3/96	1/3
20	Submit Phase 1 Draft Final Report	1/3/96	1/3/96	1/3
21	Update Program Plan for Phase 2	1/26/96	1/26/96	1/26
22	Complete 20% Testsequence 1 Objectives	1/31/96	1/31/96	1/31
23	Tank Design Review (50% Design Complete)	2/28/96	2/28/96	2/28
24	Complete 80% Test Sequence 1 Objectives	3/30/96	3/30/96	3/30
25	Test Sequence 1 Data Review	4/30/96	4/30/96	4/30
26	Submit Tank Module Design Data Book	6/30/96	6/30/96	6/30
27	Test Sequence 1 Extrapolation Complete	8/30/96	8/30/96	8/30
28	Ship LH2/LO2 Tank Module To MSFC	9/30/96	9/30/96	9/30

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Integrated Propulsion Technology Demonstrator

Task 4 - Program Management

ID	Description	Start	Finish	1995–1998 (J J A S O N D / J F M A M J J A S O N D ...)
29	Acquire Engine I/F Final Spec.	10/1/96	10/1/96	10/1 From NRA 8-11, 1A
30	Submit System Definition/Requirements Update	11/15/96	11/15/96	11/15
31	Initiate Phase 3 (Tri-Propellent Integ. Cold Flow Test)	1/3/97	1/3/97	1/3
32	Submit Phase 2 Draft Final Report	1/3/97	1/3/97	1/3
33	Update Program Plan for Phase 3	1/24/97	1/24/97	1/24
34	TS # 2 Test Readiness Review	2/24/97	2/24/97	2/24
35	Ship Subsystems Module To MSFC	2/28/97	2/28/97	2/28
36	Complete 20% Test Sequence 2 Objectives	4/30/97	4/30/97	4/30
37	Submit AETF Thrust Structure Design	5/30/97	5/30/97	5/30
38	Complete 80% Test Sequence 2 Objectives	6/30/97	6/30/97	6/30
39	AETF/IPTD Integration Design Complete	7/30/97	7/30/97	7/30
40	Test Sequence 2 Data Review	8/30/97	8/30/97	8/30
41	Submit Model Validation Draft Report	10/30/97	10/30/97	10/30
42	Test Sequence 2 Extrapolation Completed	11/30/97	11/30/97	11/30

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Integrated Propulsion Technology Demonstrator

Task 4 - Program Management

ID	Description	Start	Finish
43	Initiate Phase 4 (Integrated Engine Sys. Test)	1/3/98	1/3/98
44	Submit Phase 3 Draft Final Report	1/3/98	1/3/98
45	Update Program Plan for Phase 4	1/26/98	1/26/98
46	Ship AETF Integration Hardware To MSFC	2/28/98	2/28/98
47	TS # 3 Test Readiness Review	5/15/98	5/15/98
48	Submit Test Sequence 3 Test Objectives Draft Report	5/15/98	5/15/98
49	Complete 20% Test Sequence 3 Objectives	7/30/98	7/30/98
50	Complete 60% Test Sequence 3 Objectives	9/15/98	9/15/98
51	Complete 80% Test Sequence 3 Objectives	10/30/98	10/30/98
52	Test Sequence 3 Data Review	11/30/98	11/30/98
53	Final Program Review & Report Submittal	12/20/98	12/20/98
54	Conclude	12/23/98	12/23/98